B. M. L.
No 675

151 300
3820

UNIVERSITY OF BRISTOL

MEDICAL
LIBRARY

Presented by

B. M. L.

Rest. Med. 18

SHELF

A
NEW SYSTEM
OF
PHYSIOLOGY,

COMPREHENDING

THE LAWS BY WHICH ANIMATED BEINGS IN
GENERAL, AND THE HUMAN SPECIES IN
PARTICULAR, ARE GOVERNED, IN
THEIR SEVERAL STATES OF
HEALTH AND DISEASE.

IN TWO VOLUMES.

VOL. II.

By RICHARD SAUMAREZ,
SURGEON TO THE MAGDALEN HOSPITAL.

LONDON:
Printed for and ſold by T. Cox, at his Medical Library, *St. Thomas's-ſtreet, Borough*; J. Johnson, *St. Paul's Church-yard*; G. G. and J. Robinson, *Paternoſter-row*; Murray and Highley, *Fleet-ſtreet*; F. and C. Rivington, *St. Paul's Church-yard*; and Egerton, *Charing-Croſs.*
M.DCC.XCVIII.

UNIVERSITY
OF BRISTOL
MEDICINE

ADVERTISEMENT.

I FEEL it proper to ſtate, that Dr. Haighton has publicly taught for theſe three or four years that the ſpleen performed the office which I have deſcribed, and that he was led to adopt this opinion from the experiments which he had made.

CONTENTS

OF

VOLUME II.

CHAP. I.

OF THE ENERGY OF THE LIVING PRINCIPLE OF THE HUMAN SPECIES IN THE PROCESS OF EVOLUTION.

The formation of the different tunics by which the embryo is enveloped—the nature of the placenta—how formed—how connected with the fœtus—the evolution of the fœtus, &c. &c. &c. - - - page 1

CHAP. II.

ON PREDISPOSITION IN GENERAL.

Prediſpoſition exiſts before organic action, as in the fœtal lungs and other fœtal organs—prediſpoſition is a power of acting, before action has taken place—this power requires a *proper ſubject matter* on which to operate—the lungs require air, the ſtomach food, &c. &c.—the energy of this power acting on theſe ſubſtances produces *action*—the actions of health, &c.—prediſpoſition to diſeaſe, what—actions of diſeaſe—the Brunonian doctrine of prediſpoſition, &c. - page 47

CHAP. III.

ON THE BLOOD, OR SUBJECT MATTER WHICH THE DIFFERENT ORGANS EMPLOY.

The colour varies in different ſyſtems, is more florid and red in the higher than in the lower order, generally white in the inſect tribe, as alſo the medulla in vegetables—the degree of union that exiſts between different parts of blood varies conſiderably—the red parts conſtantly diſpoſed to become ſolid, and to coagulate the fluid—coagulation produced by the action of chemical bodies—the blood has no power of action in itſelf, contrary to Mr. Hunter's opinion—the relation which the blood bears to the organs and veſſels—the vitality of the blood proved, &c. &c. &c. - - page 93

CHAP. IV.

OF THE MEANS BY WHICH THE BLOOD IS MELIORATED IN QUALITY FROM THE DETERIORATION IT SUSTAINS.

ON INSPIRATION.

Before parturition, the different organs of ſenſe and of ſenſation are in a paſſive ſtate, owing to the harmony that ſubſiſts between them and the medium in which they are placed—after parturition, the irritation they ſuſtain from external cauſes excites them to act—the internal capacity of the cheſt is enlarged laterally by the action of the intercoſtal muſcle; longitudinally by the action of the diaphragm—the mouth is opened by the muſcles of the face—the air ruſhes into the mouth, and, through the medium of the trachea, diſtends the bronchia, conſtituting inſpiration—the quantity of air taken in, eſtimated—the qualities of it aſcertained—a part only of the whole poſſeſſes the aptitude to be acted upon by the lungs—is ſeparated from the reſt, and abſorbed—the power by which the effect is produced, aſcertained to be a living, not a chemical, act—ſimilar to the act of digeſtion by the ſtomach—the blood meliorated by the influence of vital air, &c. &c. &c. - - - page 152

CHAP. V.

OF THE MEANS BY WHICH THE BLOOD IS DISTRIBUTED FROM THE LUNGS TO THE DIFFERENT PARTS OF THE SYSTEM.

It proceeds from the lungs through the medium of four pulmonary veins to the left auricle and ventricle of the heart—from the left ventricle of the heart, it is conveyed into the aorta, and by various ramifications is diſtributed to the whole of the ſyſtem—the arteries deſcribed, &c. &c. &c. page 188

CHAP. VI.

ON THE LINNÆAN CLASSIFICATION OF THE ANIMAL KINGDOM.

The whole animal kingdom divided by Linnæus into ſix claſſes. —Claſs 1. Mammalia.—2. Aves, Birds.—3. Amphibia.—4 Piſces, Fiſhes.—5. Inſecta, Inſects.—6. Vermes.—Characters of each, &c. &c. page 259

CHAP. VII.

OF THE MEANS BY WHICH THE BLOOD IS SUPPLIED IN POINT OF QUANTITY FROM THE WASTE IT SUSTAINS.

ON THE DIFFERENT SPECIES OF ALIMENT THAT ARE EMPLOYED BY DIFFERENT ANIMATED SYSTEMS.

The aſſimilating organs of different ſyſtems examined—of herbivorous and carnivorous animals in general, with relation to their food, and that of the human ſpecies in particular—the food moſt congenial to man pointed out, &c. &c.

page 276

CHAP. VIII.

THE AGENTS BY WHICH THE SENSIBLE PROPERTIES OF SOLID FOOD ARE DESTROYED, WITH RESPECT TO BULK OR QUANTITY.

OF MANDUCATION—OF THE TEETH—OF DEGLUTITION.

The food comminuted by maſtication, acted upon by the ſaliva, and

and reduced into a pultaceous maſs—propelled through the œſophagus into the ſtomach, or organ of aſſimilation, &c. &c. page 302

CHAP. IX.

OF THE POWERS BY WHICH FOOD IS ASSIMILATED, AND CHYLIFICATION PERFECTED.

OF THE STOMACH.

The fabric of the ſtomach deſcribed—deſtined to be a ſecretory organ for the production of gaſtric juice—its qualities—its power—its uſe aſcertained and proved by the experiments of Dr. Stephens, Mr. Hunter, &c. &c. —The different degrees of aptitude in different ſpecies of food proved—the relation which it bears to the food—the aſſimilation of the food—how accelerated—how retarded—the action of the food upon the ſtomach—the operation of medicine—poiſons, &c. &c. page 315

CHAP. X.

OF THE PANCREAS.

Its ſituation—how ſupplied with blood—its fabric deſcribed—proved to be a ſecretory organ—this ſecretory power ſometimes paſſive—ſometimes active—when active it forms the pancreatic juice—its ſenſible quality aſcertained by analyſis—how and where conveyed—its uſe. - page 356

CHAP. XI.

OF THE SPLEEN.

It is ſupplied with a large quantity of blood—it is deſtitute of an excretory outlet, and therefore does not appear to perform a ſecretory office—it does not ſeem to be an eſſential, but an auxiliary organ, deſtined to ſupply with blood the ſtomach and pancreas upon extraordinary occaſions—experiments made by Dr. Haighton prove this to be its uſe—the qualities of the blood examined—conveyed by the ſplenic artery and returned by the ſplenic veins. page 362

CHAP.

CHAP. XII.

ON THE HEPATIC SYSTEM.

The ſtructure of the liver—its evolution more active in the fœtal than in the adult ſtate—has a large quantity of blood diſtributed to it—but its ſecretory office dormant—in the adult ſtate it is ſupplied with venous blood for its ſecretory office, and with arterial for its ſupport—its ſecretory office exerted, and bile formed—the cauſe of this difference in the formation of bile—proceeds from the liver ſympathiſing with the ſtomach—of the vena portæ, how it ariſes—how it terminates into pori biliarii, and the blood then converted into bile—the nature of hepatic bile—of cyſtic—its decompoſition, &c. the mode of its operation examined and proved—the primary and the ſecondary uſe of bile—of hepatic and cyſtic. page 369

CHAP. XIII.

OF THE POWERS BY WHICH CHYLE IS ABSORBED AND BLOOD SUPPLIED.

OF THE LACTEAL VESSELS.

Their ſource—their fabric—their action—the quality of the matter they take up—the quantity—the relative degree of their action at different periods of life—&c. &c. page 416

CHAP. XIV.

OF THE LYMPHATIC ABSORBENT VESSELS.

Divided into two ſets—1ſt, thoſe that ariſe from the ſurface of the body, and abſorb things from without—2dly, thoſe that ariſe from within, and abſorb different parts of the ſyſtem itſelf—their actions excited under different circumſtances, which are particularly ſtated—Mr. Hunter's opinion examined, and proved to be an erroneous one, &c. &c. page 423

CHAP. XV.

OF THE MEANS BY WHICH THE BLOOD IS DEPURATED FROM THE DETERIORATION IT HAS SUSTAINED, AND HOW CONVEYED.

OF THE VEINS.

Their origin—their fabric—their mode of termination—the difference of them from arteries pointed out—the power by which the blood is propelled through them—the term *circulation* diſputed, &c. &c. page 437

CHAP XVI.

OF THE DIFFERENT DEGREES OF POWER IN THE VASCULAR ORGANS OF DIFFERENT SYSTEMS.

In vegetables—in fiſh—in amphibia and animals of an higher claſs—the relative degree of velocity with which the blood is moved in theſe different ſyſtems, - - page 445

CHAP. XVII.

OF THE DIFFERENT DEGREES OF POWER IN THE RESPIRATORY ORGANS OF DIFFERENT ANIMATED SYSTEMS.

Stronger in man and quadrupeds than in the amphibia or fiſh—the colour of the blood in theſe different ſyſtems—and in different ſyſtems of veſſels, &c. &c. - page 459

CHAP. XVIII.

OF ANIMAL HEAT.

Produced and increaſed by the actions of the ſyſtem—black blood therefore is hotter than florid, in the pulmonary artery than in the pulmonary veins, proved by experiment—that animal heat is cauſed by animal action is further proved from the evolution of ſenſible heat at different periods of life, in different diſeaſes, and in different orders of animated beings—their temperature examined and compared, &c. &c. page 472

CHAP. XVIII*.

OF THE EXCRETIONS IN GENERAL.

OF THE URINARY EXCRETION, OR FIRST MODE.

The kidneys deſcribed—ureters—bladder of urine—the quality of urine—analyſis of urine, &c. &c. - page 490

CHAP. XIX.

ON PERSPIRATION, OR SECOND MODE OF EXCRETION.

The quality of the aëriform matter aſcertained by different experiments—the quantity alſo.—2. Quality and quantity of the fluid perſpired, &c. &c. - - page 496

CHAP. XX.

ON EXPIRATION, OR THE THIRD AND LAST MODE OF EXCRETION.

The diaphragm uſeful in expiration by diminiſhing the longitudinal capacity of the thorax—is of no ſervice in inſpiration, as ſtated by ſome—in extraordinary caſes the abdominal muſcles co-operate with the diaphragm in depreſſing the ribs, and in producing a more complete diminution in the internal capacity of the thorax—by means of which the azotic air is expelled, as deleterious and foreign—its qualities noxious, and the cauſe of diſeaſes. - - - page 503

CHAP. XXI.

ON DEATH,

Cauſed by the privation of living energy—the means conſiſt in the action of the excretory organs being ſtronger than that of the incretory—accompanied by a total ceſſation of organic action, and conſtitute the intermediate ſtate between organic action and diſſolution. page 512

CHAP.

CHAP. XXII.

ON DISSOLUTION, CAUSED BY THE ENERGY OF NATURE.

NATURE the agent by which it is cauſed—putrefaction and fermentation the means—a total decompoſition between all the parts—the effect produced is the end—Nature and Life examined, and found totally oppoſite in their action—Life the organizing—Nature the diſorganizing principle, &c. page 517

CHAP. XXIII.

OF COMMON MATTTER.

The different ſpecies—the cauſe of elective attraction—the ſun the fountain of light, neither hot nor cold—by its combination with opaque matter heat is produced—comets very numerous, &c. - - - - page 531

CHAP. XXIV.

OF THE ARRANGEMENT OF DIFFERENT SPECIES OF COMMON MATTER. - - - - page 542

A NEW

A
NEW SYSTEM
OF
PHYSIOLOGY.

CHAP. I.

OF THE ENERGY OF THE LIVING PRINCIPLE OF THE HUMAN SPECIES IN THE PROCESS OF EVOLUTION.

The formation of the different tunics by which the embryo is enveloped—the nature of the placenta—how formed—how connected with the fœtus—the evolution of the fœtus, &c. &c. &c.

IT is not preciſely aſcertained, what is the interval that enſues in the human ſpecies between conception, or the generation of a living principle, and the depoſition of it in the uterus. From the analogy that ſubſiſts among viviparous animals in general, we may preſume, that in the human ſpecies in particular, the ovum, in which the living principle is contained, paſſes through the fallopian tubes in a very gradual manner; and that it is a day or two perhaps before it is finally depoſited in the uterus *.

During this interval, a conſiderable action takes place from the veſſels that are ſituated upon the internal ſurface of that organ; an effuſion of coagulable lymph enſues, by means of which, the os uteri is rendered impervious and hermetically ſealed; the communication, which in the unimpregnated ſtate it retained with the vagina, becomes ſo completely obliterated, that, when the ovum is propelled from the fallopian tubes into the uterus, inſtead of being expelled as it would otherwiſe be, it is retained, and abortion effectually prevented. This effuſion is not confined to the cervix uteri; it extends to the whole of the internal ſurface (with the exception perhaps of

---

* In rabbits it was three days in paſſing; but as the fallopian tubes of theſe animals are much longer than the fallopian tubes of the human ſpecies, we may preſume, that in the latter the paſſage is effected in a ſhort period.

the parts where the fallopian tubes open); a thick coating is formed, which has received the appellation of tunica decidua, caduca, or ſpongy chorion. This membrane forms a conſiderable projection, which is found to proceed from a duplicature in its conſtruction: the diviſion of this one tunic into two, has given riſe to a diſtinction in the appellation of each; the former is known by the name of tunica decidua uteri; the latter, by the name of tunica decidua reflexa: the perfect evolution of the latter is ſoon attained; for it not only ceaſes to grow, but in two or three months totally diſappears: whether it is removed by abſorption, or whether an adheſion takes place between it and the tunica decidua uteri, is uncertain. The tunica decidua uteri in appearance is irregular and granulated; in conſiſtence it is thick, and in ſtructure extremely vaſcular; the veſſels with which it is ſupplied ariſe from the uterus, by the action of which it was formed: that this is the caſe is proved from hence, that an injection paſſed from the uterine arteries will completely fill the veſſels of the tunica decidua. It is probable, in order to afford the uterus time ſufficient to elaborate theſe tunics, that an interval enſues between the moment of conception, and the depoſition of the ovum in utero; in order that the medium which is deſtined for the reception of the ovum may be properly accommodated and prepared.

The embryo itſelf is inveſted and protected by two tunics of its own. It is the exiſtence of theſe tunics which gives the firſt ſenſible evidence that conception has taken place; for although their evolution is ſo far advanced, that they can be detected, the embryo which they envelop is not ſufficiently emerged from its pure and immaterial nature to be viſible to organs of ſenſe. The external of theſe tunics is called chorion, and by Haller, membrana media; the internal one is called amnion: the former is more ſolid and compact, leſs tranſparent and more vaſcular, than the latter. The ſtructure of the latter is ſo very delicate, that it is perfectly poliſhed and tranſparent, containing a ſmall quantity of gelatinous fluid, called liquor amnii, and which is deſtined to be the immediate and proximate recipient by which the ovum is contained, and in which the living principle of the offspring reſides.

Theſe two coats, ſtrictly and rigidly ſpeaking,

ing, belong to the fœtus excluſively, as much as the tunica decidua belongs to the mother; for, although the veſſels with which they are ſupplied can be injected from the fœtus, through the medium of the umbilical veſſels, they cannot be injected from the mother through the medium of the uterus: on the contrary, the tunica decidua can be filled from the mother alone, through the medium of the uterine arteries, but not from the fœtus through the medium of the funis.

It is a matter of uncertainty, whether the fœtal tunics are formed at once, or in ſucceſſion; it is very probable that they are formed in ſucceſſion, as we behold in the ova of oviparous animals, where the yolk alone exiſts in the ovarium, and the white is added to the yolk by the action of the oviduct (fallopian tube), and the ſhell is finally depoſited to the whole by a ſecretion from the uterus *.

The corculum of the vegetable ſeed, and the cicatricula in the egg of oviparous animals,

---

* It muſt be remarked, that in the caſe of extra-uterine fœtuſes, either one or both theſe tunics have been found to exiſt; ſo that it is very probable they were formed during the period of fœcundation, or at the fimbriæ.

and

and the various parts by which they are protected and ſurrounded, are analogous to the liquor amnii, and to the membrane by which it is contained, however different they may appear in the mode of their conſtruction.

Such is the active power of vegetable life, that, although it requires the farinaceous matter of which the cotyledons are compoſed for the firſt efforts of its evolution, it ſoon poſſeſſes power ſufficient to aſſimilate ſubſtances foreign to itſelf.

The power of animal life in this reſpect is leſs perfect: the ovum is filled with a quantity of food, congenial to the nature of the living principle, upon which it firſt acts, and out of which organization is formed, until it has acquired a ſufficiency of power to ſubſiſt on food entirely foreign to itſelf: on the contrary, ſuch is the comparative indigency of the higher order of animated ſyſtems, that they not only depend on the maternal conſtitution for nouriſhment and ſupport, but for a medium alſo in which to reſide. However different the means may be in each, the end is evidently the ſame in all; Providence having in view the evolution of the living principle which is generated, and the final cauſe of fœcundation.

It is the LIVING PRINCIPLE, which the ſeed and the ova contain, that conſtitutes the architect by which the machine is erected; it is the baſe on which the whole ſtands; it is the cauſe of the peculiarity in the ſex; it is the bond of its elementary parts; it is the power by which its various organs are evolved, and the whole ſyſtem protected and preſerved from putrefaction and decay *.

The

---

* I am happy to avail myſelf of the high authority of the learned Cudworth to ſtrengthen the opinion I have formed of the active power of Life.

" In the efformation of the bodies of animals, it is one and the ſelf-ſame thing that directs the whole: that which contrives and frames the eye, cannot be a diſtinct thing from that which frames the ear; nor that which makes the hand, from that which makes the foot: the ſame thing which delineates the veins, muſt alſo form the arteries; and that which fabricates the nerves, muſt alſo project the muſcles and joints: it muſt be the ſame thing that organizes the heart and the brain, with ſuch communications between them; one and the ſelf-ſame thing muſt always have in it the entire idea and the complete model or platform of the whole organic body. For the ſeveral parts of matter diſtant one from another, acting alone by themſelves without any common directrix,

being

The Principle of Life therefore, as a cauſe, may be contemplated in the abſtract, as ſeparate and diſtinct from the matter into which it is received, and through which its actions are produced: it is by the evolution of this living principle from a ſtate of dormant capacity into energy and action, that the paſſivity of common matter is overcome; although of itſelf totally formleſs, it becomes organized; although totally inert, the power of action is imparted to it: the matter of which the organized ſyſtem is compoſed, when deprived of the participation of the living principle, is as imbecile and inert as the ſhoe without the foot,

being not able to confer together, nor communicate with each other, could never poſſibly conſpire to make up one ſuch uniform and orderly ſyſtem and compages, as the body of every animal is.

"It muſt be one and the ſame thing which forms the whole, or elſe it could never have fallen into ſuch uniform order and harmony. Now that which is one and the ſame, acting upon ſeveral parts of matter, cannot be corporeal." P. 163.

"If there be any plaſtic nature that acts regularly and artificially in order to ends, and according to the *beſt wiſdom*, though itſelf not comprehending the reaſon of it, nor being clearly conſcious of what it doth; then there muſt of neceſſity be *a perfect mind* or *intellect*, that is a *Deity*, upon which it depends." P. 172.

or as the muſical inſtrument without the art and power of the muſician.

It is not the farinaceous matter of which a ſeed is compoſed, the animal gluten with which an egg is filled, or the atom of mucus in which the primordia of the embryo are received, which conſtitutes the power, by the energy of which organization is elaborated and action ultimately produced: if we were to ſubject either or all of thoſe ſubſtances to chemical analyſis, and aſcertain the ſenſible and chemical qualities they ſeverally poſſeſs, we ſhould find that by chemical analyſis the mere matter of which they are compoſed would yield the ſame product as the vegetable matter of any other ſeed, or as the yolk of any other egg, or perhaps as the mucus of any other part: and finally, if theſe bodies were deprived of the living power which they contained, they would undergo the uſual changes of decompoſition by the proceſſes of fermentation and of putrefaction.

The living principle which the ovum contains, bears the ſame relation to the matter into which it is received, as the painter does to the canvas on which he draws; it is the former that poſſeſſes the power, it is the latter which contains mere aptitude alone: if the canvas poſſeſſed any particular quality whatever, whether of colour or of figure, it would be ill adapted to receive thoſe which the art and ſkill of the artiſt intended to diſplay. If the animal gluten by which the embryo is ſurrounded, poſſeſſed any property beſides that of aptitude alone, it would be ill adapted to anſwer the purpoſe for which it was eſpecially deſigned: like the figured canvas, the ſenſible qualities of the animal matter would not only oppoſe, but effectually prevent the living principle from creating organs out of matter unorganized, and from imparting powers of action to thoſe organs although compoſed of matter totally imbecile and inert.

That Providence ſeems to have this principle eſpecially in view, of accommodating the nature of the recipient to the degree of power in the agent, is not only evident from what we have ſeen in the various ſyſtems in general we have examined, but it is illuſtrated by the human ſpecies in particular.

Of the Formation of the Placenta in general, and Maternal Portion in particular.

If the tunica decidua be examined before the firſt month of geſtation is expired, the whole appears of a granulated ſtructure: but one part there is which is evidently more elevated than any of the reſt: this irregularity ſeems to proceed from a number of veſſels that project on its ſurface: this projected portion diminiſhes in breadth, but increaſes in thickneſs; and finally inoſculates with a portion of the chorion to which it is oppoſed; and where a ſimilar proceſs takes place, it is by the combined action of both, and by the union of both, that placenta is elaborated and completely formed.

The portion of the placenta which was formed from the tunica decidua, is called the maternal portion: the one that was formed from the chorion is called the fœtal; the two taken together, when forming one aggregate maſs, are called *placenta.* The attachment that ſubſiſts between the uterus and the internal portion is effected by the medium of cellular membranes, through which a multitude of veſſels immediately proceed: as theſe veſſels paſs from the uterus to the placenta, they diminiſh in magnitude, and increaſe in number, and finally terminate by an exhalant extremity and a returning vein: the exhalant extremity diſcharges its contents on the ſides of the cells of which this portion of the placenta is compoſed*: the returning vein carries the groſſer parts of the blood back again into the maternal ſyſtem.

Of the Fœtal Portion of the Placenta.

Where the maternal portion of the placenta ends, the fœtal begins: it is apparently of a membranous ſtructure, and conſtitutes the immediate recipient of the fluid which was depoſited from the veſſels we have juſt deſcribed. In the human ſpecies this fluid is apparently of a ſerous nature; but in the larger order of quadrupeds, as cows, &c. where the quantity is more abundant, and its ſenſible properties more obvious, this fluid is of a more milky and chylous quality. Whether it obtains this character by the action of the cells of the maternal portion of the placenta, or whether it preſerves its ſerous quality until it is depoſited upon the fœtal portion, is a queſtion that cannot be decided: it would appear probable, that the uterine arteries of the mother convey blood through the maternal placenta, and depoſit it in the fœtal part: the former conſtitutes the organ from whence it is immediately obtained, and forms the medium through which it is conveyed; the latter conſtitutes the agent by which it is aſſimilated and accommodated to the nature of the fœtal ſyſtem, for the nutrition and ſupport of which it was eſpecially deſigned, and of which it may then be ſaid to conſtitute a part.

---

* That theſe veſſels ariſe from the uterus is evident from this, that an injection paſſed through the uterine arteries will diſtend the veſſels and fill the cells: and finally, that theſe veſſels terminate in the cells of the maternal portion, and do not penetrate into the fœtal portion, is proved from the effects of injection alſo. For, although both the veſſels and cells of the maternal portion are filled, no part of the fœtal portion is affected, nor are there any of its veſſels that are filled in conſequence: ſo that, although there is an union and connection between both portions by the medium of cellular membranes, there is a complete and decided ſeparation between them with reſpect to veſſels.

The neceſſity of ſuch an arrangement muſt be apparent to every reflecting mind, in order that the nature of the matter which the living principle is to receive, may be exactly adapted to the period of its evolution. If it were not for this arrangement; if the maternal blood, inſtead of being conveyed mediately through the placenta, were received immediately; the conſequence would be, that the *old* blood of the mother would be received, unprepared by the *fœtal* ſyſtem, for the ſupport of which it was not adapted. The various ſenſible qualities which the maternal blood poſſeſſed, muſt have rendered it unapt and unfit for the firſt effort which the living principle makes to evolve itſelf, and to impart its own nature to the matter which poſſeſſes the aptitude to receive its participation. Inſtead of the maternal blood being modelled by the energy of the living principle, and organization formed, the contrary would be the caſe. The maternal blood would undergo, in the fœtal ovum, the ſame changes that it is wont to do, either when it is extravaſated within or without the ſyſtem: inſtead of the living principle acting upon and arranging it, the blood would make a mere coagulum; a *rudis indigeſtaque moles.*

The maternal portion of the placenta therefore conſtitutes the medium between the uterus to which it is attached, and the fœtal portion of the placenta; and which itſelf forms the connecting medium between the maternal and fœtal ſyſtems. The placenta, therefore, is the ſource from whence the fœtus obtains nouriſhment, and from whence the motion of the blood has its origin: that it is the origin, is evident, becauſe the uterus is the fountain from whence the blood is received; the placenta the organ by which it is prepared; and the veſſels which ariſe from thence conſtitute the media by which it is conveyed.

The neceſſity of ſuch media is not only apparent with a view to the proceſs of aſſimilation, but for the purpoſe alſo of abating and accommodating the velocity with which this nutritious matter is conveyed. Deleterious and deſtructive indeed would be the effects that muſt enſue, if the maternal blood were to be conveyed to the embryo by the muſcular force of the maternal organs. The ſtrength of the maternal heart and arteries would have been employed, and been ſubſervient to the debile condition of the fœtal ſtate: ſubſiſting without

out power, it would have been diſorganized without reſiſtance.

A conſtruction of organs ſo diſcordant and deſtructive, was never deſigned by that Being who is the fountain of all wiſdom, and the ſource of all power. Beauty and ſymmetry exiſt in every part, that harmony may be the reſult of the whole.

The momentum of the maternal circulation is abated in this part by two different means; not only by an increaſe in the number of veſſels, that their diameter might be leſs, but by the final and complete termination of the exhalant outlet of the uterine arteries on the ſides of the maternal placenta.

It is therefore neceſſary to trace the progreſſive changes that take place in theſe parts, that we may be able to underſtand how the connection between them is ultimately effected.

Of the Evolution of the Embryo.

It appears that the ovum in which the living principle reſides, ſubſiſts, for two or three weeks after it has been generated, in an oviparous ſtate; reſiding, it is true, in the uterus, without having any immediate connection with it: it extracts nouriſhment from the medium alone by which it is ſurrounded, as the chick does from the albumen and yolk, or as the kangaroo when it reſides in the uterus, and exiſts on the gelatinous matter by which it is involved. About the third or fourth week two white ſpots begin to appear, floating as it were in a ſemi-tranſparent liquor, which the amnion contains. One of theſe ſpots proves to be the rudiments of the embryo, the other the rudiments of the *funis.* Soon after this period, one of theſe ſpots ſeems as it were divided into two ſmall veſicles, one of which conſtitutes the head, the other the trunk. The whole of the embryo is not larger than a pea: there is neither ſymmetry of figure nor apparent organization: there is not a fœtus in miniature; for, with reſpect to form, the embryo is a mere chaos in all its parts. About the ſixth week the organs of ſenſe may be detected, and the face is marked by features; although at the expiration of the ſecond month, the whole taken together does not meaſure above one inch in length.

The evolution which the embryo ſuſtains is not equal throughout the whole: there are ſome parts whoſe evolution has ſcarcely begun, whilſt others have attained conſiderable magnitude.

If the internal organization be examined before the ſecond month, no bond of continuity ſeems to exiſt between the different organs, and geſtation has proceeded a conſiderable way, before evolution is ſo far advanced that a connected ſyſtem can be ſaid to be formed. Such however is the fixed and unerring nature of the laws by which it is governed, that there is not only a determinate period for the evolution of particular parts, but for the perfection of the whole. The different organs that are more immediately deſtined to preſerve and perfect the ſyſtem, when the fœtal ſtate ends, are eſpecially diſtinguiſhed by the rapidity of their growth, and the magnitude they have attained when the adult ſtate begins. We may enumerate as the firſt in order,

1. The head with the organs of ſenſe, and the nerves that are connected with them.

2. The mouth, trachea and lungs.

3. The heart and arterial ſyſtem.

4. The œſophagus and ſtomach, with its auxiliary organs, namely the ſpleen, the pancreas and hepatic ſyſtem.

5. The omentum, the inteſtinal canal and lacteal veſſels.

6. The bladder of urine, &c. &c. &c.

Theſe are the various inſtruments, in the evolution of which the energy of the living principle in the fœtal ſtate ſeems to be particularly exerted, and which are endowed with power ſufficient to act after parturition: on the contrary, there are various other parts that are either comparatively ſmall, or whoſe evolution has ſcarcely commenced: under the ſecond claſs may be mentioned the bones, many of the voluntary muſcles attached to them, the generating and ſexual organs, the venous ſyſtem, the lymphatic abſorbent veſſels of particular parts, the teeth, the hair and nails, &c. &c. &c.

Before the evolution of the different organs, it is impoſſible that their ſpecific powers can be properly diſplayed. The principle from whence their ſpecific action proceeds, is in capacity alone, and in a dormant ſtate: it is then a principle without an organ; a producing cauſe without a proper ſubject; ſimilar to the ſcience of the muſician without an inſtrument on which that ſcience can be exerted.

During the evolution of the organs, the ſpecific power they contain cannot be perfect, becauſe the living principle is then engaged in the proceſs of evolution and of growth; and it is not until the perfect evolution of the ſyſtem is attained, and the living principle only employed in preſerving what it has produced and perfected, that the period is arrived when the various ſpecific powers which the different organs poſſeſs can be properly diſplayed. The parts therefore on which the living principle is moſt active with reſpect to growth, muſt be moſt paſſive with reſpect to ſpecific power. The reaſon is, that two ſpecific actions cannot properly exiſt together in the ſame place at one and the ſame time. The ſpecific power therefore of the fœtal organs cannot begin, not only from a deficiency of power and the imperfect ſtate of their evolution, but from the abſence of thoſe various ſubſtances upon which they are deſigned to act. The eye therefore has the capacity to ſee, without actually ſeeing; and the other ſenſes are in a paſſive condition: the brain is in a ſtate of growth without conſciouſneſs; the nerves without ſenſation; the muſcles without voluntary motion; the ſtomach without digeſtion; the inteſtinal canal without periſtaltic motion; the lacteal veſſels without abſorption; the lungs without reſpiration; and the heart with a very imperfect circulation.

That fœtal evolution does enſue without organic action, is evident from the inſtances we frequently behold of fœtal evolution taking place, whilſt the different organs ſo eſſential to the adult are totally abſent in the fœtal ſtate. I have ſeen a fœtus without a head, others with a head but without brain; ſome without lungs, others without heart or lungs; many have been found deſtitute of abdominal viſcera, and with various other mal-conformations of their ſyſtem. Although theſe organs were either defective or totally abſent, the other parts of the ſyſtem were found perfectly evolved, and had attained their fullneſs of growth and ſymmetry of form. The different organs therefore, although endowed with life, are for the moſt part deſtitute of organic action: if they were deſtitute of life, they would undergo the ſame changes, like other dead matter of putrefaction or of fermentation.

It is far otherwiſe. The evolution of the living principle, by means of which organization is formed, conſtitutes the true end of fœtal exiſtence: the particular and ſpecific action of the organs is for the moſt part ſuſpended, until they are ſufficiently evolved to be able to perform in the beſt poſſible manner the end for which they are deſigned. Whilſt therefore the living principle which the embryo contains organizes and arranges the blood it receives, the different organs which are eſſential to the formation of blood in the adult are perfectly paſſive in the fœtal ſtate.

If fœtal evolution depended on organic action in general, a neceſſity would exiſt for the preſence of the various ſubſtances upon which the organs are eſpecially deſigned to act: the admiſſion of air would be neceſſary to call forth the action of the lungs; the introduction of food, neceſſary for the action of the ſtomach; and the various organs that are of an auxiliary nature would conſequently be rouſed from their dormant ſtate into activity and action.

If the fœtal ſyſtem were expoſed to the action of thoſe cauſes, the fœtal would reſemble the adult ſtate; its life would be a life of choice, not of neceſſity; of choice indeed without the power of chooſing, of action without the power of acting; of indigency and want, but totally deſtitute of ſufficient means by which its neceſſities could be ſupplied; becauſe the organs of conſciouſneſs and of ſenſe are totally dormant and paſſive, not only from the imperfect ſtate of their evolution, but from the total abſence of the various means by which their action is called forth. The fœtus therefore ſeems to conſtitute a medium ſtate, as forming a connected part of the maternal conſtitution, and as ſeparated from it by its own individual exiſtence. That there is an individual exiſtence in both, ſeparate and diſtinct from each, is evident from this, that the life of the child frequently terminates whilſt that of the mother continues; and on the contrary, the mother is ſometimes deprived of her own exiſtence, whilſt that of the fœtus remains for a limited time. It is therefore neceſſary to examine the mode of connection that ſubſiſts between both, and the object for which it is eſpecially deſigned.

Of the Umbilical Vein.

The fluid which had been depoſited from the uterine veſſels through the medium of the maternal placenta, and which had been aſſimilated and prepared by the fœtal portion, is abſorbed by a number of ſmall veſſels which ariſe with open mouths from the ſurface of that organ: theſe veſſels, inſtead of increaſing in number and diminiſhing in ſize as the uterine arteries, diminiſh in number but increaſe in ſize, until they finally unite and congregate into one veſſel, which has been called the *umbilical vein.*

The *umbilical vein* is of conſiderable length, and receives, in common with the placenta, a covering from the amnion, which gives to the whole a ſmooth appearance. After having paſſed through the umbilicus of the fœtus, it aſcends on the right ſide, and, after entering the liver, divides into ſeveral branches. One branch, and which is the moſt conſiderable of the whole, unites with the vena portarum, and is diſtributed to the liver itſelf. Another branch, which has received the appellation of canalis venoſus, proceeds in a more direct courſe: it unites with the largeſt of the hepatic veins; they proceed to the cava inferior, and enter the right auricle of the heart; ſo that the umbilical vein conſtitutes the medium through which the fœtus obtains nouriſhment from the fœtal placenta, of which it is the ſource.

The blood which the right auricle receives in the fœtal ſtate, inſtead of being conveyed altogether into the right ventricle, as it is in the adult, and from the right ventricle through the medium of the pulmonary artery to the lungs, becomes diſtributed in a manner totally different: this difference proceeds from the peculiarity in the conſtruction of the parts, ariſing no doubt from the difference that ſubſiſts between the fœtal and the adult ſtate, and the ſeveral ends each has reſpectively to fulfil. The blood which the fœtus receives is eſpecially deſigned to anſwer the purpoſe of fœtal evolution, without a view to the ſpecific action of the organs. Inſtead therefore of beholding in the fœtal ſtate an unequal and an increaſed proportion of blood diſtributed to particular organs, as we find in the adult, the only inequality we behold in the diſtribution of blood ſeems eſpecially deſigned for evolution, but not for ſecretion. The additional quantity of blood which the liver receives, inſtead of being ſubſervient to the ſpecific power of the liver, in the formation of bile, anſwers the eſpecial purpoſe of organic formation.

That the evolution of the living principle, in the proceſs of organization, is the true end of fœtal exiſtence, is further proved from the comparative condition of the veſſels that ſupply different organs; of thoſe that ſupply them with blood for nouriſhment and ſupport, and of thoſe that are ſubſervient to their ſpecific or ſecretory office.

The bronchial and pulmonary arteries may ſerve as an illuſtration of this point. The former, which is eſpecially deſigned to convey nouriſhment to the lungs, is relatively larger in the fœtal than it is in the adult ſtate: on the contrary, the latter, which anſwers the ſpecific action of that organ, is proportionally ſmaller in the fœtal than in the adult condition. In the former period, the ſmall quantity of blood which paſſes through is only ſufficient to preſerve it in a patent ſtate: in the latter ſtate it conveys the whole maſs of blood which the ſyſtem contains. Seeing then that an inequality in the diſtribution of the blood is eſpecially prevented, we muſt conclude, that the fœtal ſyſtem is provided with means by which a more equal diviſion of the blood may take place, and each organ be ſupplied with a proper quantity.

Of the Manner in which the Blood is diſtributed *.

The membrane or ſeptum that ſeparates the right auricle of the heart from the left, does not ſeem to have been perfected ſo ſoon as the other parts of that organ: inſtead of being cloſed during the fœtal ſtate, it remains open, and this opening it is that has been called *foramen ovale.*

The *foramen ovale* is rather of a round than of an oval figure; the edges are very thick and muſcular; this muſcularity is probably owing to a decuſſation from the muſcular fibres of the ſurrounding parts. The valve which afterwards conſtitutes the ſeptum between both auricles, ſeems to lie eſpecially towards the left ſide: for, although the mode of its conſtruction very eaſily admits the tranſmiſſion of blood from the right to the left ſide, it puckers up in a ſack-like form, if it be puſhed from the left to the right ſide: it is of a membranous ſtructure, of a delicate conſiſtence, but poſſeſſing conſiderable ſtrength.

---

* It is unneceſſary for me to give a general account of the conſtruction of the heart, which muſt be known to every tyro in phyſiology. I ſhall therefore content myſelf by ſtating the peculiarities it poſſeſſes.

The blood, therefore, which the right auricle receives, goes partly through the foramen ovale to the left auricle, and partly through the medium of the right ventricle into the pulmonary artery.

The pulmonary artery, ſoon after its origin, has a canal which ariſes from its ſides, and which terminates in the aorta below the arch called *ductus arterioſus*, and which is larger than the united trunks of the pulmonary arteries.

Such is the relative poſition of the *ductus arterioſus* with reſpect to the trunk of the pulmonary arteries, and of the aorta, that the paſſage of the blood through the former is more indirect than it is through the latter: whilſt a ſmall proportion of blood only flows through the pulmonary arteries to the lungs, the major quantity flows through the ductus arterioſus into the aorta.

The ſmall quantity of blood that goes to the lungs is returned from them through the medium of the pulmonary veins, and depoſited in the left auricle of the heart: it unites with the blood which the foramen ovale admitted from the right auricle, and is from thence conveyed through the medium of the left ventricle into the aorta alſo: it is from thence either diſtributed to the different parts of the ſyſtem, for their nouriſhment and ſupport, or is returned back to the placenta through the medium of the *umbilical arteries.*

* From an attentive review of the conſtruction

---

* "Mr. Hunter ſays, that the fœtal heart, by having but one auricle, by the communication between the two, and alſo one ventricle, by means of the union between the two arteries, which produces an union of blood: theſe paſſages, however, are ſhut up almoſt immediately after birth; or, at leaſt, the canalis arterioſus, which immediately prevents the foramen ovale from producing its former effects: therefore it is not ſo neceſſary it ſhould be ſhut up in the adult. I have ſeen it to common appearance as much open as in a fœtus."—*Hunter on the Blood*, p. 136.

"Again, ſays he, in the fœtus in utero, the aorta at the beginning tion of theſe different parts, it appeared very probable to me, that it was eſpecially deſigned to equalize and balance the diſtribution of the blood to the ſyſtem in general, with a view

beginning from the ventricle is larger than in the adult, in proportion to the quantity of blood that paſſes through the foramen ovale: and beyond the entrance of the canalis arterioſus, the aorta is increaſed in proportion to the ſize of that canal; and it is at this part that its ſize is to be eſtimated. This probably makes the aorta beyond the entrance of the canalis arterioſus twice as large as in the adult, in proportion to their ſize; but the drawback upon this is the placenta. He therefore concludes, that the aorta of a fœtus is not only larger than of an adult, but larger in that proportion which the ſize of the fœtus bears to the ſize of the placenta: that the capillary arteries in the fœtus are as numerous, if not more ſo, than they are in the adult; the trunks are as numerous, and, as far as they could be traced, they ſeem to ſend off the ſame number of ſmaller branches; and, in many parts, we find a great many more ſmaller veſſels in the fœtus than in the adult; more eſpecially in all growing parts, as in the eye, in the membrane of the ear, in callus, in granulations, &c. In the adult, indeed, it is very certain that there are many arteries that are obliterated: hence it appears, that a fœtus is much more vaſcular than an adult, and has a much larger quantity of blood in proportion to its ſize; and that the heart muſt ſtill be larger and ſtronger in proportion to move this blood, which will ſtill probably circulate in the ſmaller veſſels with leſs velocity."

to its evolution, rather than allow a local determination to take place, that might call forth the ſpecific action of the organs at a time when that action could have anſwered no purpoſe. The ſmall degree of ſpecific action that the different organs diſplayed, as was proved by the ſmall quantity of ſecreted fluids that was produced, even to the total privation of them, and the ſlowneſs with which the blood was conveyed through the fœtal ſyſtem, ſeemed to confirm me in that opinion. It is however proper for me to ſtate, that in the ſecond volume of the Anatomy of the Human Body, which has lately been publiſhed by Mr. John Bell of Edinburgh, the œconomy of theſe parts ſeem to him to be deſigned for very different purpoſes: he ſuppoſes, that the ductus arterioſus is eſpecially deſtined, not ſo much to prevent the blood from flowing through the pulmonary artery to the lungs, "*as for giving to the blood of the aorta the propelling power of both ventricles; for the peculiarity of the conſtruction gives the full force of the right ventricle to the blood of the aorta, in addition to that of the left.*"

He further ſays, "that the deſign of nature in this peculiarity in the conſtruction of the fœtal heart, is to prepare a double one, and keep it in reſerve for the circulation of the adult; but to uſe it as a ſingle one in the fœtus. The two auricles communicate ſo freely by the foramen ovale, that the two auricles are as one: the two ventricles both deliver their blood into one veſſel, the aorta: the two ventricles are as one: the blood arrives by the cavas, fills the right auricle, and in the ſame manner fills through the foramen ovale the left auricle; ſo that the auricles are as one, and filled by one ſtroke. The two auricles act at once, and ſo the ventricles alſo are filled by one ſtroke: the aorta receives the blood of both ventricles at one ſtroke; ſo that, in the ſtricteſt ſenſe of the word, the fœtus has but one ſingle heart." P. 185.

It is very true that the fœtus has but one ſingle heart. The comparative ſmallneſs of the waſte it ſuſtains renders it unneceſſary that the motion of the blood ſhould be ſo rapid as in the adult, where the waſte of the ſyſtem is very conſiderable. The concluſion therefore is an erroneous one, which ſuppoſes that the ductus arterioſus is eſpecially deſigned "to give to the blood of the aorta the propelling power of both ventricles."

If this were the deſign of this conſtruction, the conſequence would be, that the motion of the blood through the fœtal ſyſtem would be much more rapid than it is through the adult; and inſtead of a portion of the blood flowing from the right auricle through the foramen ovale to the left, the whole would go to the right ventricle, in order that its contractile power might be more eminently exerted by a more abundant quantity of blood.

That the motion of the blood in the fœtal ſyſtem, is much ſlower than it is in the adult, is evident to every man who has paid any attention to the ſubject: the contractions of the heart are ſo imperceptible and eaſy, that they generally cannot be detected ab externo: it is not until the fœtal ſyſtem has been rouſed and excited, either in conſequence of the action of reſpiration, or from the operation of external cauſes, that the contraction of the heart is increaſed, that it becomes equal to, and even exceeds, what we behold it in the adult. I have frequently known the pulſation of the funis not more than fifty ſtrokes in a minute,

nute, whilſt the maternal pulſe was at one hundred.

In natural caſes of parturition, where the child is expelled immediately after the membranes have been ruptured, if the hand be applied to the region of the heart before reſpiration has taken place, no pulſation is then to be felt. Some addreſs is here neceſſary; for, if reſpiration has begun, or the liquor amnii has been completely evacuated, the action of the heart is conſiderably increaſed, and may be diſtinctly felt; and I have frequently obſerved, in preternatural caſes of parturition, where it was neceſſary to rupture the membrane and turn the child, that the pulſation of the heart could not at firſt be diſcovered by the application of the hand to the region of the heart; although in other caſes, where the membranes had been ruptured and the liquor amnii evacuated, the pulſation of the heart could be diſtinctly felt. This appears to me to be an action produced in conſequence of the irritation which the fœtal ſyſtem has ſuſtained from the loſs of the medium in which it was accuſtomed to reſide, or from an increaſed excitement, owing to the contraction of the uterus upon the body of the fœtus.

A lady under my care was taken in labour: the membranes broke in the uſual way, and delivery was effected by one pain: on applying my hand to the region of the heart before reſpiration began, no pulſation whatever could be perceived. Reſpiration took place; the pulſation of the heart was then felt and continued. This lady had twins; and as it frequently happens that the ſecond child is born with the membranes entire, I therefore waited patiently for the event of the pain. One pain not only expelled the child, but the whole ovum with it. I put the whole in a proper veſſel, and carried it to the table, where I had a moſt perfect opportunity to feel the region of the heart, through the membranes, which I left perfect and undivided. After having aſcertained with the utmoſt attention that the heart either did not contract, or, if it did contract, that it did it ſo faintly as not to be felt; I concluded either that the child was ſtill-born, or that there was little or no contraction of the heart. I therefore continued my hand on the left ſide of the thorax, extending my fingers under the diaphragm; I then ſeparated the membranes, with a view of admitting the external air.

Reſpiration immediately began, and three very full and diſtinct ſtrokes at pretty conſiderable intervals took place, and an exceſſively quick and ſmall pulſe ſucceeded, as is uſual on ſuch occaſions. Three other caſes of a ſimilar kind have fallen under my obſervation, and I conceive the fact perfectly aſcertained.

In many of the caſes where this pulſation could be felt, it was at firſt remarkably ſlow, although that of the mother was remarkably quick. That the exiſtence of a ductus arterioſus is not with a view of increaſing the force by which the blood is conveyed, is further proved from the power which the veſſels alone poſſeſs of performing that office, where no heart is found to exiſt; and finally, by the proviſion which the ſyſtem poſſeſſes, of conveying the blood without this increaſed power. It is with a view to this, that the blood is returned by *arteries*, and not by *veins*;—by arteries, in order that they might convey the reſiduary quantity of the blood, without the neceſſity of any increaſed action of the heart.

The iliac arteries, inſtead of proceeding to the inferior part of the fœtal ſyſtem, diſtribute a few veſſels only to the pelvis and neighbouring parts: the two arteries then take a curved direction on the ſide of the bladder of urine, paſs through the umbilicus of the fœtus, and have conſequently received the appellation of *umbilical arteries.*

The *umbilical arteries* become enveloped by the ſame membrane as the umbilical vein, and *the whole taken together* conſtitute the funis, or navel-ſtring. Theſe arteries are in general much larger than the vein, and for the moſt part are found taking a ſpiral turn round it until their final termination in the placenta.

Although the umbilical arteries have the ſame conſtruction which we behold arteries in general poſſeſs, it appears that they differ from them in the mode of their termination: inſtead of terminating by an exhalant outlet and a returning vein, it does not appear that they poſſeſs any exhalant outlet whatever: the branches either inoſculate with each other, or terminate in umbilical veins alone. That this is the conſtruction of theſe parts, and that the umbilical arteries have no open extremity either in or upon the placenta, is proved from the effect of injection.

1. If one of the umbilical arteries be in-

jected, no part of the injection becomes extravaſated on the ſurface of the placenta, unleſs it be from a rupture of the veſſel.

2. That they have frequent anaſtamoſes with each other, is evident from this, that by injecting one of them the others become completely filled.

3. That the umbilical arteries have a direct communication with the umbilical veins is proved alſo from hence, that if an injection be forced into the artery, it will not only diſtend and fill the vein, but the whole of the fœtal ſyſtem.

Thus then it appears that the placenta conſtitutes the organ in which the motion of the blood terminates, and conſequently that it is from thence it has its origin: it ends at the extremity of the umbilical artery, and begins at the open orifices of the umbilical vein. The nutritious matter which the umbilical veins abſorb from the fœtal placenta, affords a conſtant ſupply of freſh materials for the evolution of the fœtal ſyſtem, without the action of its own reſpiratory or chylopoetic organs: it is this maternal blood, which had been aſſimilated by the fœtal placenta to the nature of the fœtal ſyſtem, that conſtitutes the ſource from whence the fœtus is ſupplied: and where the blood is in the pureſt ſtate in which it can be conceived, it is then generally of a crimſon colour, ſimilar to the arterial blood of the adult. The waſte it ſuſtains of the pureſt and beſt parts of the whole, from the exhalant termination of the arteries, in ſupplying the fœtal ſyſtem, produces a conſtant deterioration of the reſt; and it progreſſively loſes this crimſon, and aſſumes a purpliſh colour. A neceſſity therefore exiſts, that it ſhould be kept in a ſtate of conſtant motion, in order that every part may recover the loſs it ſuſtains, and receive a proper ſtate of melioration from the placenta. Such however is the ſmallneſs of the waſte it undergoes in the fœtal ſtate, where evolution alone exiſts, without ſpecific organic action, when compared to the adult, where there is evolution and ſpecific action together, that the neceſſity exiſts that a portion *only* of the whole ſhould return through the umbilical arteries to the placenta (not perhaps one third part of the reſt).

This organizing proceſs continues for nine calendar months after the fœtus has been generated, before it is ſufficiently perfected to reſiſt the operation of the external cauſes by which it is aſſailed, and to aſſimilate the crude and inanimate ſubſtances on which it is deſtined to feed. When we reflect on the evolution which the fœtus has ſuſtained during the period above mentioned, we muſt confeſs that its living power was moſt active, and that the nouriſhment which the maternal ſyſtem conveyed was particularly adapted to the nature of the fœtal ſyſtem. The fœtus ſeems to obtain an almoſt total increaſe, without ſuffering ſcarcely any waſte; the whole of the matter which the exhalant arteries depoſit becomes organized, and the paucity of excretory matter, which the excretory organs contain, proves that the organization permanently remains *.

---

* The bladder of urine, during the whole period of geſtation, does not receive more than two or three ounces of urine; and there is no other reſervoir in which it can be contained. In different quadrupeds, more eſpecially of the larger claſs, there is an additional reſervoir for the reception of the excretory matter which is produced: there is a canal that ariſes from the fundus of the urinary bladder, called *urachus*, and which terminates in a membranous ſac called *alantois*, it is ſituated between the chorion and amnion, and which increaſes in magnitude according to the period of geſtation.

The fœtus is placed in the beſt poſſible poſture that can be conceived: the head lies inverted towards the cervix uteri, the chin reſting upon the thorax: the arms are applied cloſe to the ſides, and the fore-arms inflected upon the arms; the palms of each hand and fingers filling the hollow of the neck: the thighs are drawn up towards the flanks; and the legs tucked up under the thighs: the ſpine, which admits of a conſiderable curvature, gives to the whole a globular form; a form the moſt perfect that can be conceived; comprehending *within* its circumference the greateſt poſſible ſpace that can be meaſured, and in which the whole is contained.

The changes alſo which the uterus itſelf undergoes are not leſs ſtriking: it enlarges in magnitude in proportion to the evolution which the fœtus ſuſtains: the neck of the uterus, which in the virgin ſtate evidently projected beyond the body, progreſſively loſes in the impregnated ſtate this projecting point, and ultimately aſſumes a regular oval figure. This alteration, however, does not take place at the early period of geſtation; the alteration is apparent after the fifth month; it proceeds more rapidly from the fifth to the ſeventh month, than from the ſeventh to the ninth: at the ſeventh month, two thirds of this projection have diſappeared, and at the ninth month nothing but a ſmall tubercular ſtructure is apparent.

The uterus is ſituated at firſt within the cavity of the pelvis; it preſerves this ſituation for the three firſt months after impregnation: but in proportion as the evolution of the ovum takes place, the uterus ſympathizes with the whole, and ſuſtains a conſiderable degree of enlargement; inſtead of being depreſſed by the increaſed weight it has to ſuſtain, it progreſſively riſes above its uſual ſituation: at the third or fourth month, the os uteri, inſtead of being placed in the centre of the pelvis, is nearly on a level with the brim: at the fifth month, the fundus uteri is half way between the brim of the pelvis and the umbilicus: at the ſixth month, it is as high as the umbilicus itſelf: at the eighth month, the fundus is midway between the umbilicus and diaphragm; and at the ninth month it has aſcended as far as the diaphragm itſelf.

The diſtenſion that the gravid uterus ſuſtains, does not proceed from the ſame cauſes that we behold in inanimate matter, where an increaſe of dimenſion produces a diminution of thickneſs: on the contrary, in proportion as the uterus increaſes in dimenſion, the increaſe of thickneſs progreſſively follows; ſo that, when the full period of geſtation is attained, it is very ſubſtantial in its fabric.

It is not the ſubſtance of the uterus alone that undergoes the increaſe of evolution, but the veſſels alſo with which it is ſupplied: theſe veſſels become ſo much enlarged, that they have in conſequence obtained the name of ſinuſes: they purſue a torquated or ſerpentine courſe, in order that the momentum of the blood may be weakened, as it might otherwiſe endanger the ovum, which it is deſtined to ſupply.

When we reflect on the amazing alteration which theſe different organs undergo, the mind is ſeized with aſtoniſhment: it confeſſes that the whole is the work of a Divine Artificer, that alone can poſſeſs the mighty power of elaborating, out of means at firſt ſo ſlender and ſimple, a fabric ſo wonderful and intricate in all its parts.

Of Parturition.

When the full period of geſtation is accompliſhed, the harmony that ſubſiſted between the containing and contained parts, between the uterus and the ovum, entirely ceaſes. It is probable that it ceaſes, becauſe the time deſtined for the evolution of both is expired; ſo that the action of the uterus is excited from this cauſe, rather than from the effect of over diſtenſion.

We have frequent inſtances where particular organs are excited at particular periods, and where that excitement is limited and defined in its duration: it is eſpecially the caſe with the uterus itſelf, in the proceſs of menſtruation. The acceſſion, return, and duration of this function in the healthy ſtate is ſo regular, that many women know the minute almoſt when it begins and ends. Why not then ſuppoſe that the period neceſſary for the evolution of the uterus is equally limited and defined; and that it has ſuſtained the acmé of its growth, at the expiration of nine calendar months after conception has taken place? From the ſympathy that ſubſiſts between the ovum and the uterus, it is very probable, that this is the period which is eſpecially deſigned for fœtal exiſtence; ſo that when the fœtus has attained the acmé of perfection, the uterus itſelf has ſuſtained the full diſtenſion of which it is ſuſceptible: it therefore acts according to the power which it inherently poſſeſſes. This power is reſident in the muſcularity of its fabric; by the energy of which, a partial, and afterwards a general contraction of theſe fibres takes place. The contractions at firſt begin at the fundus uteri, and progreſſively extend towards the cervix; they begin at diſtant, and are repeated at frequent intervals: theſe intervals become gradually ſhorter, and the forces of the contractions increaſe in power. The changes which the os uteri undergoes, prove the effect they have upon that part: inſtead of continuing impervious as before, it gradually dilates, and the membranes, by which the fœtus is inveſted, are found progreſſively to protrude.

In proportion as the contraction of the uterus increaſes, its internal dimenſion progreſſively decreaſes: the fœtus therefore becomes gradually forced into the cavity of the pelvis:

the diaphragm and abdominal muſcles all cooperate, by their action, to diminiſh the capacity of the abdominal cavity, and to force the uterus into the pelvis; the contraction of the uterus ultimately overcomes the reſiſtance which its contents afford, the membranes burſt, the liquor amnii is diſcharged, and the child, placenta, &c. become ultimately expelled through the pelvis, from its reſidence in the maternal ſyſtem. The labour and anguiſh of the parent, till that awful and important proceſs is accompliſhed; the diſeaſe that ſometimes, and the weakneſs that always ſucceeds; the lamentation and cries of the infant as ſoon as it is born, all prove the ſenſibility and weakneſs of the human frame.

CHAP. II.

ON PREDISPOSITION IN GENERAL.

Prediſpoſition *exiſts before organic action, as in the fœtal lungs and other fœtal organs—prediſpoſition is a power of acting, before action has taken place—this power requires a* proper ſubject matter *on which to operate—the lungs require air, the ſtomach food, &c. &c.—the energy of this power acting on theſe ſubſtances produces* action—*the actions of health, &c. —prediſpoſition to diſeaſe, what—actions of diſeaſe—the Brunonian doctrine of prediſpoſition, &c.*

IF the animated ſyſtem be examined, and compared in the mode of its ſubſiſtence in the fœtal and in the adult ſtate, a great and ſtriking difference is found to ſubſiſt between both. Such is the harmony that ſubſiſts between the fœtus and the medium in which it is ſituated, that the whole is in a paſſive condition. The thorax is depreſſed, and accommodated to the collapſed condition of the lungs; the abdominal muſcles are relaxed, and in harmony with the parts they encloſe: the various muſcles by which the motions of the jaw are produced, are paſſive alſo; ſo that no part of the liquor amnii can be introduced into the mouth; the various organs of conſciouſneſs and of ſenſe are deſtitute of the energy they are found ſo eminently to diſplay in the adult ſtate. The extremities alone—the parts that are more immediately deſtined to be the inſtruments of voluntary motion, ſeem occaſionally to act by virtue of the ſpecific power they poſſeſs; as is evident by the ſenſation which the mother feels, and of which they are evidently the immediate cauſe *.

Although theſe different organs are in a paſſive ſtate, no doubt can exiſt but that they poſſeſs a *capacity to act*; and that they only require proper ſubjects on which that capacity may be exerted, and diſplayed in the production of action. It is this capacity of action,—of the eye to ſee, of the ear to hear, of the tongue to taſte, of the nerves to feel, of the lungs to reſpire, of the ſtomach to digeſt, &c. &c. &c.—which I denominate PREDISPOSITION.

---

* Whether theſe movements proceed from the irritation which the nerves of ſenſe ſuſtain, when they come in contact with the uterus, without the intervention of the liquor amnii, or whether it be a beginning of voluntary power which the mind exerts, is a queſtion I am not at preſent prepared to decide.

Prediſpoſition therefore appears to be a ſtate of dormant power, or a capacity of power; it reſembles the ſpring coiled up, before it re-acts, by virtue of the elaſticity inherent in it: it reſembles the impreſſion engraved on the ſeal, before it is participated by the wax; it is like the gun-powder before it detonates and explodes. The gun-powder poſſeſſes the capacity to explode, the ſeal to impreſs figures, and the ſpring to re-act. This ſtate, however, of capacity is very different from the ſtate of energy and action, when the various phænomena of exploſion, of impreſſion, and of re-action are produced: theſe different bodies, in which theſe powers in capacity reſide, require certain circumſtances external to themſelves for the diſplay of thoſe powers: for example, the ſpring requires an unreſiſting medium, (a medium with ſmall reſiſtance); the ſeal, a ſubject matter, in conſiſtency ſoft and yielding; and the gun-powder requires a particular condition of the atmoſphere. In like manner, the power which the animated ſyſtem inherently and eſſentially contains, demands a certain temperature in the medium in which it reſides; particular ſpecies of food, and particular conditions of it, before that power, paſſive and dormant, can become power active, and the phænomena produced of organic action.

The dormant power which the organs poſſeſs would never have been rouſed, and the phenomenæ of organic action produced, if the organs had not proper ſubſtances on which to operate: a proper aptitude, therefore, and fitneſs in the ſubſtances which the different organs receive, becomes eſſentially neceſſary; and it is then that the ſtate of prediſpoſition, or of dormant power, becomes a ſtate of power active, and the phænomena of living action enſue: it is in this power which the ſyſtem altogether, or the different organs in particular ſeverally poſſeſs, either of operating upon, or in reſiſting the operation of external ſubſtances, that the ſyſtem may be ſaid to poſſeſs a *prediſpoſition to health.* The powers of preſervation and of reſiſtance are not only limited and confined; but they vary in different conſtitutions, and in different parts of the ſame conſtitution at different times. Some conſtitutions poſſeſs the prediſpoſition to health in ſo eminent a degree, that they paſs through the long courſe of a long life in the undiſturbed enjoyment of it. If the prediſpoſition of the organs in general be examined, it is found that particular organs are prediſpoſed to act upon particular ſubſtances; the lungs are prediſpoſed to act upon the air; the ſtomach upon animal and vegetable matter, and on fluids of various kinds; the lacteals upon the chyle; the glands upon the blood; the bladder upon the urine; the inteſtines upon the fæces, &c. &c. So long as this relation continues to ſubſiſt, of power in the organs, and aptitude in the ſubject matter, health is preſerved and diſeaſe prevented: the relation therefore which the animated ſyſtem in a *healthy ſtate* bears to things *external*, is the relation of *ſtrength and of power*; and the relation which *external* things bear to the *healthy* ſtate, is that of *aptitude alone.*

Of Aptitude.

The neceſſity of a proper aptitude to be acted upon in the matter which is expoſed to the action of the living ſyſtem, is proved by the difference that ſubſiſts in the quality of the nouriſhment which different ſyſtems, and various parts of the ſame ſyſtem, demand. In the fœtal ſtate, whilſt the evolution of the ſyſtem was taking place, and before the organs had acquired the power of acting, the embryo received nouriſhment at once properly prepared, without the action of its own aſſimilating organs.

It is with a view to the neceſſity of aptitude, that Providence has ſupplied the maternal ſyſtem with organs that produce a fluid fitted to be acted upon by the infant ſtomach, for the nouriſhment and ſupport of the infant frame. As ſoon as parturition therefore is accompliſhed, an increaſed action takes place in the breaſts *. The glandular parts convert

---

* When Laurence Sterne uſed to examine himſelf naked in the looking-glaſs, and contemplate the uſes for which the different organs he beheld were deſigned, he could eaſily account for the exiſtence of all, his nipples alone excepted: the exiſtence of theſe uſed to cauſe him the greateſt perplexity of mind, becauſe he never could find any uſe for them. He thought them of no more uſe to him, than they are to thoſe mothers who do not ſuckle their own children when they have health and ſtrength equal to the taſk.

It however appears to me, that if *Sterne* had ſtudied the uniformity with which Providence proceeds in all its operations, vert the blood they receive into milk: if it were poſſible to analyſe the fluid which the fœtal placenta has aſſimilated, and if we could compare its properties with that of milk, I am perſuaded that there would be found to ſubſiſt a conſiderable analogy between both, becauſe it is the firſt tranſition which the fœtus undergoes in the mode of its ſubſiſtence, between living on matter immediately prepared by means of

operations, and the gradual difference that ſubſiſts between the different links in the chain of animated exiſtence, he would have ſeen that there is a neceſſity for a ſyſtem where the breaſts ſhould ſubſiſt, without being of any particular uſe. Of all the mammalia claſs, the human female, in this reſpect, is the moſt imperfect. If the chain ended with her, either ſhe would be deſtitute of a breaſt, or, if ſhe poſſeſſed one, it would be like that of the male: if ſhe were deſtitute of this organ, her very nature would be changed, and ſhe would probably belong to ſome of the lower order of animated beings; and if ſhe poſſeſſed one like that of the male, it would be of no ſervice: the chain of difference, therefore, does not ſtop at the female, where the mammæ are wanted for the nouriſhment of the offspring; but it proceeds to the male, where it ultimately terminates, and is of no other uſe to him, than that of preſerving the regularity in the chain of animated exiſtence, from the higheſt to the loweſt, from the moſt perfect to the moſt imperfect.

its auxiliary organs, which is at once converted into blood; or receiving matter from the mother, which muſt be firſt aſſimilated to the nature of its own ſyſtem, by the action of its own organs. In the fœtal ſyſtem, therefore, blood is formed immediately by the power of the placenta alone: in the adult ſtate, it cannot be formed without the medium of different organs, of the lungs in particular, and chylopoetic organs in general.

In proportion as the infant ſyſtem acquires ſtrength and perfection, the ſtomach poſſeſſes the capacity to act upon food of a more ſolid nature: an evolution, therefore, of the teeth enſues, in order that the matter received may be comminuted and maſticated, rendered apt and fit for the ſtomach to aſſimilate. The power in the infant ſyſtem of living on ſolid matter, points out the propriety of abandoning its former mode of ſubſiſtence: inſtead, therefore, of living by ſuction, as it uſed to do, and for which purpoſe its lips and gums were eſpecially calculated, it employs the teeth with which it is ſupplied, and ſubſiſts on fluid and ſolid food together.

When we reflect on the gradual evolution which the teeth ſuſtain, the delicacy and weakneſs of the firſt ſet, we muſt neceſſarily conclude, that none but ſuch food as is eaſy of comminution ought to be introduced, as alone poſſeſſing the aptitude to be acted upon by the infant ſtomach. But when the evolution of the ſyſtem is further advanced, and more eſpecially when it has attained its ſtandard of perfection, the milk teeth drop off, and another ſet more compact and durable than the former ſupply their place, in order that the various and diſcordant ſpecies of food to which the mental appetite is diſpoſed to indulge, may be rendered apt and fit for the action of the ſtomach. On the contrary, at the period of old age, when the powers of the ſyſtem are verging to decay, the ſtomach in general firſt feels the change. The teeth periſh, not only becauſe the muſcular powers by which they are moved are not ſufficiently ſtrong to maſticate food of a nature too ſolid, but becauſe the ſtomach is too weak alſo to digeſt and aſſimilate it into chyle. The teeth and mouth therefore are eſpecially deſtined to prepare food from without, and make it in harmony with the parts within, that it may poſſeſs the aptitude to be acted upon, and qualified to be aſſimilated into blood. The chylopoetic organs are therefore deſtined to perform the ſame function on food, as the maternal portion of the placenta upon the blood. The maternal placenta, as we have ſeen, conveys nouriſhment that poſſeſſes the ſtrongeſt poſſible aptitude to be converted into fœtal blood, and which is perfected by the medium of the fœtal placenta. The guſtatory and chylopoetic organs together prepare and aſſimilate food, in order that it may be converted into blood. The difference conſiſts in the ſimplicity by which the one is effected, and the complication of the other. It is by the action of the fœtal placenta that the ſerous fluid it receives from the maternal, is aſſimilated into its own nature, and blood actually formed. The fœtus, therefore, makes blood immediately; the adult does it by different media. The chylopoetic organs prepare only the food for the lungs to perfect, ſo that it is by the combined action of the chylopoetic and reſpiratory organs together, that blood is formed; as it is by the combined action of the two portions of the placenta, that fœtal blood is produced. Great, therefore, is the error of thoſe who ſuppoſe that the placenta performs the office of lungs alone, merely for the oxydation of the blood : its office is far more important ; it performs the double and combined office of chylopoetic and reſpiratory organs together.

Aptitude neceſſary in the Air which the Lungs receive.

The neceſſity that ſubſiſts of proper aptitude in the food which the ſtomach is to receive, is equally evident in the air or ſubject matter which the lungs eſpecially demand : this neceſſity is proved by the different ſpecies of air which different ſyſtems require for their nouriſhment and ſupport. The particular kinds of air which anſwer, in the moſt eminent degree, the purpoſe of vegetable evolution, as alſo of the inſect tribe, are found particularly deleterious and deſtructive to human exiſtence. The former vegetate and flouriſh by immerſion in and abſorption of thoſe airs : in the latter, a ceſſation of all vital action enſues, it periſhes and dies. Food, therefore, which conſtitutes aptitude for the one ſyſtem, is evidently inaptitude in the other, ariſing from the different nature of the living principle in each. It is owing to the increaſed aptitude which oxygene poſſeſſes to be acted upon by the reſpiratory organs of the human ſpecies in general, that, although it is involved with double its quantity of azote, and a ſmall proportion of carbonic acid gas, it becomes ſelected and abſorbed: on the contrary, the other parts are ſeparated, and by the collapſe of the bronchia, are expelled as deleterious and foreign. So that the ſubſtances received as nutritious, are not only totally different in different ſyſtems; but the quality of the matter which is expelled as excrementitious and foreign. Whilſt vegetables act upon and devour azotic and carbonaceous air, becauſe they poſſeſs the aptitude to receive the participation of life of thoſe particular ſyſtems, they are perpetually excreting oxygene, becauſe it has not the aptitude to retain the participation of the living principle which it had received: it is therefore decompoſed in the living ſyſtem in which it reſided, and of which it once formed a part, and is expelled out of it, On the contrary, in the human ſyſtem, the carbonaceous and azotic airs which the different parts of the living ſyſtem contain, are found unapt to preſerve and retain the participation of the living principle which they had received; they therefore become perpetually decompoſed, and are excreted out of it, through the medium of different organs which are eſpecially allotted this particular office; viz. by the terminated extremity of the pulmonary arteries, by the exhalant veſſels ſituated on the ſurface of the ſkin, and by the power of the kidneys through the medium of the urine. Carbonaceous air and nitrogene therefore is azotic air (deadly) with reſpect to the human ſpecies, but pure air with reſpect to the vegetable ſyſtem; and oxygene, in ſome caſes, may be conſidered as azotic air, with relation to ſome ſpecies of the vegetable creation. Purity, therefore, has the relation of aptitude, and impurity of inaptitude alone: but none of theſe airs are vital *per ſe*; they only become the fit ſubjects for the reception of vitality, which is imparted to them by the living power of the organs to which they are applied.

Of Aptitude in the Medium.

The neceſſity of aptitude in the food which different ſyſtems require for their nouriſhment, extends to the medium in which they are deſtined to reſide.

It is with a view to this neceſſity, that different ſyſtems are placed in different media, according to the eſpecial nature of each; and that the degree of protection they receive, correſponds to the power or weakneſs of their living principle. Such is the living power of vegetables, and of the lower order of animals, that the ovum by which it is contained becomes ſeparated from the parent by whom it was produced. The parturition of vegetables is effected by the rude blaſt to which it is expoſed, and it afterwards evolves in the ſpot where it was depoſited. Fiſh in general, and moſt of the oviparous animals, are expoſed to the ſame deſtiny. It is the higher order of animals, whoſe living principle demands the protecting medium of the maternal ſyſtem for the purpoſe of its evolution, until its organization is ſufficiently ſtrong to reſiſt the viciſſitude of climates to which it is afterwards expoſed.

When we reflect on the proviſion which Providence has made, in order that the tranſition of the fœtal into the infant ſtate with reſpect to food, might be as ſlight as poſſible *, we muſt neceſſarily conclude, that the change in the temperature of the medium ought not afterwards to vary in any conſiderable degree; but as the temperature of the air is lower in the adult than what it was in the fœtal ſtate, it would appear reaſonable to conclude that infants, although they ſhould be kept very warm, ought not to be kept in a medium ſo high as they were in before; and I am ſatisfied, that with reſpect to temperature, and to the nature of their food, it ought to reſemble, as far as it is poſſible, what it was in the fœtal condition †.

---

* By the affinity that milk bears to the matter which the placenta conveys.

† It was my intention to have inveſtigated the different climates, and the different ſituations beſt adapted for different ſyſtems; and, on the contrary, thoſe that ſeemed particularly deleterious to their exiſtence. As this ſubject would neceſſarily extend to a conſiderable length, although it is certainly connected with the preſent queſtion, I muſt decline it for the preſent.

Of Action in general, of Health in particular.

As ſoon as parturition is accompliſhed, and the fœtus is depoſited in a medium fitted for its reception; the different organs with which it is ſupplied, are rouſed from the ſtate of prediſpoſition, or of dormant capacity, into energy and action. In proportion as the ſtate of prediſpoſition departs, the ſtate of energy accedes. The difference that ſubſiſts between both conſiſts in this: in the one caſe, the organs have the power to act, without having ſubſtances on which to operate; in the other, the power which the organs poſſeſs is immediately called forth by the application of the various ſubſtances which they demand, and upon which their action can be properly exerted. *Prediſpoſition*, therefore, in the organs, reſembles the ſcience of the artiſt, whilſt he is deprived of the materials on which his ſcience can be diſplayed in the different works of art: it reſembles the ſcience of the painter without his canvas; of the mathematician without his plumb and line: on the contrary, *the action* of the organs reſembles the architect furniſhed with materials, and actually employed in building: it reſembles the painter occupied in drawing figures upon his canvas; the mathematician, when he applies his ſcience in the very act of menſuration, &c. &c. The power to act therefore exiſted before that power was actually exerted, in the ſame manner as the prediſpoſition to act in the lungs, &c. exiſted before action took place: it only took place when the ſubject matter (air) fitted for their action was applied: it was the ſame with the ſtomach, by the introduction of food; of the eye, by the application of the rays of light; of the ear, by the tremulous or vibratory motion, excited in the air that is conveyed to the internal ear by the medium of the tympanum; of volatile bodies to the noſe, through the medium of the olfactory membrane; of ſapid bodies, through the medium of the mucus and cuticle which cover the tongue; of impreſſion, through the medium of the cuticle and cutis on the cutaneous nerves. The power, therefore, or capacity, is reſident *within.* The *means* by which that power is called forth into energy comes *from without;* the *reſult* of which is the *production of organic action.*

The action produced is not the *cauſe* of life, as has been falſely and erroneouſly ſuppoſed, but merely an *effect* of it. Life, as we have ſeen before, may and does ſubſiſt without organic action, although organic action cannot ſubſiſt without the exiſtence of life. Life had a prior exiſtence to the organization, and organization itſelf to the action produced. Life is the primary and efficient cauſe, of which organization is the ſecondary or inſtrumental cauſe; and organic action itſelf is the final cauſe, which proceeds from the living power of the organs acting upon ſubſtances foreign to themſelves, when they poſſeſs a proper aptitude to be acted upon. So long as this relation continues to ſubſiſt, of *power* in the organ and *aptitude* in the ſubject matter, the ſyſtem receives the ſupply it perpetually demands; the ſenſation of health and of ſtrength, ſo delightful and agreeable, may be then ſaid to exiſt: on the contrary, when there is a mal-conformation of the organs, or the ſubject matter applied to them is either improper from exceſs or defect, or from the nature of its ſenſible qualities, diſeaſe takes place.

Of Prediſpoſition to Diſeaſe.

Prediſpoſition to diſeaſe exiſts when the organs of which the whole of the ſyſtem is compoſed are mal-conformed, or when they have been compoſed of matter that was not fitted for the nature of the living power by which it was organized. For example, if the maternal ſyſtem, during the period of geſtation, laboured under ſome particular complaints, ſo that the blood that was conveyed through the medium of the placenta poſſeſſed deleterious properties; no doubt can ſubſiſt, but that the fœtus will ſuſtain as much injury in its formation, as the adult would do from noxious qualities in the food. I am ſure that I have ſeen caſes of this ſort. It however often happens, that the maternal ſyſtem is attacked with various complaints during the period of geſtation, and yet the fœtus is not particularly affected by them. We ſometimes ſee particular organs of the ſame ſyſtem prediſpoſed to the preſervation of health, whilſt others are the very negative of theſe: in ſome, the lungs are ſtrong, the ſtomach weak; in others, the ſtomach ſtrong, the bladder weak, &c. &c.

and in particular caſes we occaſionally behold a weakened and a mal-conformed ſyſtem altogether.

When a ſyſtem thus prediſpoſed is excited into energy, the actions that are produced are diſplayed in a manner languid and morbid; inſtead of the ſyſtem itſelf being perfectly renewed, and the different organs performing their functions as they ought, diſeaſe takes place of various kinds. If this mal-conformation ariſes from the conſtruction of the thorax, the effect is immediately felt by the lungs: if the weakneſs be reſident in the lungs themſelves, they have not the power of acting upon the air: the conſequences are therefore felt by the blood, ſo that every part of the body which is ſupplied with it, becomes in conſequence affected; not the glands alone, and the fluids which they produce, but the whole of the ſimple ſolid alſo. If the mal-conformation be reſident in the ſtomach, inſtead of the food being aſſimilated as it ought, chyle is imperfectly formed, and the blood is conſequently deprived of the conſtant ſupply it demands: if it be the lacteal or meſenteric glands, tabes and emaciation take place: if it be the kidneys or bladder, ſablonous or calculous concretions are formed * : if the mal-conformation be in the lymphatic abſorbent veſſels, anaſarca enſues : if it be in the lymphatic glands, ſcrophula and rachitis, &c. &c.

When we reflect on the ſimilitude that frequently ſubſiſts between the parent and the offspring, and the different marks which the latter very often bears, and which it evidently derives from either one or both parents ; we ſhall naturally be led to conclude, that the different organs of the infant frame participate, in a conſiderable degree, the nature of the parent ſtock : hence it is that robuſt parents generally produce ſtrong and healthy children ; and, on the contrary, weakly children are the frequent iſſues of unhealthy parents. I know ſeveral parents that have particular marks about their bodies, and which exiſt equally in the children. In one family, the mother was born with a fleſhy ſubſtance ſuſpended from the lobe of the left ear ; and although it was

---

* Mr. Gaitſkill, an ingenious ſurgeon of Rotherhithe, has informed me, that he found in a fœtus which he had an opportunity to open, a perfect calculus in the bladder of urine, of the ſize of a ſmall filberd.

cut off in her infancy, three out of five children have been born with preciſely the ſame ſubſtance ſubſiſting in the ſame part: why, then, ſhould we deny that the ſame peculiarity of conformation may take place in the different organs alſo? And as our exiſtence is hereditarily derived from our parents, in like manner our organs obtain the peculiarity of their ſtructure from them: ſo that the degree of ſtrength and of weakneſs, of health and of diſeaſe, in a great meaſure ariſes from the nature of our original formation. This ſtructure is evidently of an hereditary nature; ſo that when the prediſpoſition to action is called forth, which mal-conformed organs poſſeſs, the action that takes place, inſtead of being as it was in the healthy ſtate, reſembles the imperfect and mutilated impreſſion engraved on the ſeal: it reſembles the gun-powder hiſſing off in vapours and in ſmoke, inſtead of complete detonation: it reſembles the feeble efforts of re-action in a bad ſpring, in conſequence of the elaſticity it does not contain.

It is owing to the imperfection of the ſyſtem, or to its comparative ſtate of weakneſs in reſiſting the operation of external cauſes, that prediſpoſition to diſeaſe really and truly exiſts. When the ſyſtem operates upon external cauſes, health is preſerved, and diſeaſe prevented: on the contrary, when external cauſes operate upon the ſyſtem, or the ſyſtem has not the power to reſiſt their operation, health departs, and diſeaſe is produced.

Such is the conſtruction of all generated beings, that, whilſt their powers of preſervation and of reſiſtance are limited, the deleterious cauſes by which they are or may be aſſailed, are almoſt infinite both in number and in power; ſo that, in the full enjoyment of health and of ſtrength, all are conſtantly prediſpoſed to the operation of morbid cauſes, by which diſeaſe is produced, and often fall victims to its effects. Whilſt, in our corporeal frame, we are prediſpoſed "to all the evils which fleſh is heir to," our minds alſo are prediſpoſed "to the ſtings and arrows of outrageous fortune."

The ſyſtem is prediſpoſed to diſeaſe from accidents, becauſe the organization is not ſufficiently ſtrong to reſiſt the operation of the mechanical powers to which it is expoſed, and by which it is often aſſailed. The arrangement of its organs is frequently diſturbed; a ſolution of continuity between the parts often takes place; and ſuch is the læſion and deſtruction which the whole occaſionally ſuffers, that a ſuſpenſion of the functions neceſſary to the exiſtence of life immediately enſues.

It is prediſpoſed to diſeaſe, from the operation of ſubſtances whoſe powers do not reſide ſo much in their mechanical, as in their ſpecific or chemical qualities. The various bodies called poiſons may be arranged under this claſs, more eſpecially thoſe that are produced by the proceſſes of putrefaction and fermentation of animal and vegetable matter, or that are given out by the excretory organs of animals and vegetables in their morbid ſtate, or from particular parts of ſome animals and vegetables in their healthy ſtate. Under the firſt head may be mentioned the poiſon of plague, of typhus, of ſmall-pox, of meaſles, of lues, of itch, of rabies, &c. &c. Under the ſecond head may be ſtated the poiſon of the viper, the rattleſnake, bug, bee, &c. &c. &c.

There are various parts of the vegetable kingdom that furniſh ſubſtances ſo extremely deleterious and noxious to the human frame, that its action beomes inſtantly ſuſpended, and putrefaction immediately enſues, as the poiſon of the lauro-ceraſus, &c. &c. &c.

Finally, the ſyſtem is prediſpoſed to diſeaſe from the operation of the ſenſible qualities of chemical bodies—of fire in a ſenſible form, of lightning, of various cauſtics of an acid and of an alkaline nature; and, in ſhort, from the abuſe of any one ſubſtance that can be mentioned. The chemical properties of theſe bodies overcome the reſiſting power of the part or of the ſyſtem to which they are applied. They enter into a chemical union with it, ſo that both loſe by the combination ſome of the qualities each ſeparately poſſeſſed.

The mineral poiſons are either metallic, earthy, or ſaline, or the different compounds that are formed by them.

1. The metallic poiſons are, arſenic, mercury, antimony, copper, lead, ſilver, and gold.

2. The earthy poiſons are, calcareous earth, barytes or terra ponderoſa, and ſiliceous earth.

3. The ſaline poiſons are, the ſulphuric, nitric and muriatic acids, and the mineral alkali. The above ſubſtances conſtitute the baſe of which various preparations are formed; and it is generally found, that they become much

more

more active in their combined than in their native ſtate*.

The relation, therefore, which external things bear to the weak and the diſeaſed ſtate of the ſyſtem, is that of power and of ſtrength; and the relation that the debile ſtate of the ſyſtem bears to external things, is that of weakneſs and ſuſceptibility. When the reſiſting powers which the animated ſyſtem contains, are not equal to, or greater than, the powers external to itſelf, health departs and diſeaſe accedes. Such, indeed, is the total privation of reſiſting power in ſome conſtitutions, that nothing but prediſpoſition or weakneſs ſubſiſts, weakneſs of reſiſtance within, and ſuſceptibility to be acted upon by things without, conſtituting what is called an *irritable habit.*

That a ſtate of prediſpoſition to diſeaſe in the ſyſtem has the relation of weakneſs to the cauſes by which it is aſſailed, is proved from the difference that we frequently behold in different conſtitutions, and in the ſame conſtitution at different times. Amongſt a number of children that are often expoſed to the contagion of the ſmall-pox, many ſhall have it in the confluent, ſome in the diſtinct form; a few ſhall reſiſt the operation of the poiſon, and eſcape the diſeaſe altogether.

---

* I wiſh to have it underſtood, that I only enter upon this part of the ſubject as much as is ſufficient to illuſtrate my opinion. It is a very copious ſubject of itſelf, and it were my wiſh hereafter to arrange it as it deſerves.

Although conſtitutions ſuch as theſe are naturally ſtrong (and ſome there are that know not what diſeaſe actually is), there are various cauſes by which that prediſpoſition to health may be weakened, and prediſpoſition to diſeaſe immediately induced: theſe cauſes are called *prediſponent*, as having a tendency to weaken the reſiſting power of the ſyſtem, and to favour the operation of the *exciting* cauſes upon it.

The influence of theſe prediſponent cauſes is particularly evident in particular habits that are equally expoſed to the operation of different poiſons. Perſons who have been weakened by any cauſe, whether of body or of mind, become more ſuſceptible to be acted upon by the poiſon of typhus, of marſh miaſmata *, &c. &c.

---

* It is a very melancholy fact, that after a number of unhappy wretches have undergone ſome very ſevere operations

than thoſe who are in the full enjoyment of health: in the one caſe, it is external cauſes operating upon the ſyſtem; in the other, it is the ſyſtem operating upon external cauſes.

The influence of this principle is moſt eminently proved in thoſe diſeaſes that we frequently behold produced a long time after the reception of the poiſon: it frequently happens, that perſons in a ſtate of health (in hoſpitals, indeed, it always happens) receive various ſpecific poiſons, which the ſyſtem however has then the power to aſſimilate and deſtroy. When a ſtate of weakneſs is induced, the preſervative power of the ſyſtem becomes conſequently leſſened; the poiſon which was before in a dormant, becomes in a ſenſible ſtate; inſtead of being paſſive, it becomes active; in-

---

operations in our different hoſpitals, they are placed in wards where different contagious diſeaſes frequently exiſt. Such is the weakneſs that is induced upon the ſyſtem by the pain during the operation, by the loſs of blood, and by the antiphlogiſtic regimen afterwards purſued, that a ſtate of prediſpoſition to the reception of theſe poiſons is immediately induced, the diſeaſe takes place, and death very frequently follows. If ſeparate hoſpitals for ſurgical and medical patients cannot be obtained, particular wards ought however to be ſelected for the reception of each ſeparately.

ſtead of the organs eliminating its morbid qualities, its morbid qualities excite the action of the parts in which it is depoſited, and morbid action is produced.

The action of moſt poiſons under the ſame circumſtances, and on conſtitutions apparently alike, is pretty uniformly the ſame; as alſo the power of the conſtitution itſelf, either in reſiſting the operation of the poiſon, or in correcting its influence. The poiſon of ſmall-pox by inoculation takes eight or ten days before it produces a general influence upon the ſyſtem; and the ſyſtem itſelf requires the ſame period, before it is able to aſſimilate the poiſon which it has received, and correct the action which it has produced. It is the caſe with various fevers brought on by poiſons of a ſpecific kind. The power of the ſyſtem commonly deſtroys their operation in a certain number of days; in the meaſles, three; in the ſcarlatina, ſeven; in typhus, twenty-one, &c. &c. It is in this relation of power between the ſyſtem and the poiſon, that the doctrine of critical days ought to be founded: it muſt however appear very difficult to eſtabliſh any ſuch criteria, becauſe we are generally ignorant of the concentration and force of the poiſon, and of the reſiſting degrees of the ſyſtem either in eliminating or combating its effects. If the ſyſtem have not the power of correcting the poiſon, or of arreſting the effects it produces, the poiſon continues to act upon the ſyſtem. The morbid actions which it had excited, continue to increaſe until all vital action becomes ſuſpended, and diſſolution finally takes place.

The ſame principle equally applies to the influence of temperature: there ſeems to be a ſtandard medium moſt congenial to the human frame. Although the ſyſtem poſſeſſes the power of reſiſting within certain limits a deviation from that ſtandard; no doubt can exiſt, but that extreme degrees either of heat or of cold overcome the reſiſting power of the ſyſtem, and death is induced either immediately or mediately by the action of diſeaſe: theſe are the conſequences of the ſyſtem having loſt the power of preſerving itſelf, and of reſiſting the action of thoſe agents by which it is aſſailed.

Of the Brunonian Doctrine of Prediſpoſition, &c.[*]

It appears that Dr. John Brown's ideas of prediſpoſition were very different from thoſe I have endeavoured to explain. Prediſpoſition he defines to be "*a ſtate intermediate betwixt health and diſeaſe: the powers producing it are the ſame with thoſe that produce diſeaſe.*" P. 59. This nonſenſe would be of itſelf perfectly unintelligible, were it not for the imperfect explanation which the context affords. The context ſays, that "prediſpoſition ariſes from the ſame exciting powers acting upon the ſame excitability from which both health and diſeaſe ariſe, and is an intermediate ſtate between both." So far from this opinion being true, that a ſtate of prediſpoſition ariſes from the ſame exciting powers acting upon the ſame excitability from whence both health and diſeaſe ariſe, and is an intermediate ſtate between both, that a ſtate of prediſpoſition, properly defined, can only exiſt before the exciting powers have been applied, or before they have produced any action upon the excitability. Prediſpoſition, as we have ſeen, really and truly exiſts in the fœtal ſtate altogether; it exiſts in the collapſed lungs; in the fœtal ſtomach before it has received any food; in the organs of generation, and in various other parts. On the contrary, according to him (and, I may add, moſt others alſo), a ſtate of *prediſpoſition* is a ſtate of *poſtdiſpoſition*: it is prediſpoſition ended, and action begun; it is the origin of diſeaſe before the morbid actions of the ſyſtem have had their full ſwing. It evidently appears, that Dr. Brown had no knowledge whatever of the condition of the fœtal ſtate, of the ſtate of prediſpoſition in which it then exiſts; of the capacity of acting which it poſſeſſes, and of the power by which action is ultimately produced.

---

[*] I muſt refer the reader to the firſt volume of this Work, where the fundamental principles of the Brunonian doctrine have been inveſtigated.

In every ſyſtem whatever there is a tendency to evolution and health, before the tendency to diſeaſe and death. There is a period allotted to both: when perfection is attained, it ends, and the tendency to diſſolution begins. It would be far otherwiſe, if life were the *forced ſtate* he ſuppoſes; if it were true, " that the tendency of animals every moment is to diſſolution; that they are kept from it *not by any powers in themſelves*, but by foreign powers, and even by theſe with difficulty, and only for a time; and then, from the neceſſity of their fate, they yield to death*." If life were the forced ſtate he ſuppoſes it to be, the proper application of his exciting powers would perpetuate animal life ad infinitum: inſtead of animals being forced to die, they would be forced to live; and he might as eaſily reſuſcitate a dead animal by means of his ſtimuli, as excite motion in a paſſive top by the action of a whip. The whip may be compared to his exciting powers; the top to the ſubſtance in which excitability reſides; and the motion produced by the combined agency of the whip and top together is exactly analogous to excitement or life, which is forced and whipped out by the operation of his exciting powers acting on his excitability. It is very obvious indeed, that Dr. Brown grounded his ſyſtem upon the phenomena he beheld common matter diſplay; he ſaw excitement produced in the ſyſtem by the introduction of different ſubſtances of brandy, wine, &c. he therefore referred excitement to the brandy as its cauſe, in the ſame manner as the motion produced in the top by the action of the whip. Both caſes, however, are totally oppoſite and diſtinct: in the one caſe, the top is totally paſſive, and yields to the moving power which the whip communicates: in the other caſe, the animated ſyſtem conſtitutes the power which acts upon the brandy; the ſyſtem is the cauſe exciting, the brandy, the thing excited upon; and in this effort it is by which action is produced.

---

* Page 58.

A neceſſity evidently ſubſiſts, that the food introduced ſhould correſpond to the ſtrength or weakneſs of the ſyſtem. In atonic diſeaſes, where the ſpecific power of the aſſimilating organs is extremely weak, the ordinary kinds of aliment become unfit to be introduced; and we are obliged to reſort to food that poſſeſſes the ſtrongeſt poſſible aptitude to be acted upon in order that it may be digeſted: inſtead, therefore, of giving ſolid, liquid food is preferred; and we are taught by experience that fermented liquors and animal juices poſſeſs a ſtronger aptitude to be acted upon by the ſtomach than cold water, or acid or other ſubſtances of the ſame claſs. In proportion, therefore, as the ſtrength of the ſyſtem decreaſes, the aptitude in the aliment ought to increaſe: hence ariſes the neceſſity of giving in the latter periods of low fevers wine and brandy, when every other ſpecies of aliment is rejected unaltered and undigeſted.

It is owing to the total confuſion of ideas, to the total ignorance of phyſiological knowledge, that Dr. Brown, in the very onſet of his book, chap. i. art. 1. under the title of what he calls Explanations, but which are really and truly axioms, ſhews himſelf ignorant alſo of the diſtinction that ſubſiſts between medicine and diet. Expl. 1. "Medicine is the ſcience of preſerving the good, and preventing and curing the ill health of animals." This propoſition, I maintain it, is falſe: the means by which the good health of animals is preſerved, is not a ſcience, neither does it belong to any branch of medical knowledge: it belongs to the dietetic branch, ariſing from experience alone, and in which men totally ignorant of medicine are perfectly converſant. This knowledge extends to the whole range of the brute and even vegetable creation, amongſt which the *ſcience of* *medicine* does not yet appear to have made any progreſs. On the contrary, the practice of medicine is the art (not the ſcience: our knowledge of its operation, and the ſubject on which it operates, is as yet too imperfect to bring it to any ſcientific rule) by which diſeaſe is cured, and health reſtored; and medicine itſelf is the mean by which the end is attained *.

---

* That the practice of medicine is an art, and not a ſcience, will be very evident, if we examine the nature by which both are characterized. Art medical depends entirely on experience, on experience indeed of the infinite uncertainty that exiſts in its application to different conſtitutions, and to the ſame conſtitution at different times: on the contrary, the ſcientific knowledge of a thing depends on an intimate knowledge of the cauſe, and on the poſſeſſion of the laws on which its effects proceed. The rules of ſcience are ſo definite and conſtant, that the effects that flow from them are uniformly and invariably the ſame: it is on the immediate dependence of the effect from the cauſe, and on a knowledge of that dependence, that the inveſtigation of ſcience to the full poſſeſſion of ſcientific knowledge may be ſaid to conſiſt: the means by which this ſcientific knowledge is attained, conſiſts in the poſſeſſion of certain general truths (facts) by which the nature or eſſence of a ſubject is characterized, without the exiſtence of which the ſubject itſelf would ceaſe to ſubſiſt. It is by the poſſeſſion of theſe general truths, that we obtain the knowledge of the cauſes on which the various ſubordinate

Although it is the ſyſtem which in general poſſeſſes the power by which health is preſerved, and diſeaſe prevented, or diſeaſe cured after it actually ſubſiſts, there are various complaints which ariſe from the application of ſpecific poiſons, and which can only be cured by ſuch remedies as have the ſpecific power of uniting with and deſtroying the ſenſible properties which thoſe poiſons poſſeſs:—mercury for the lues, ſulphur for the itch, &c. &c. Theſe remedies, like thoſe poiſons, are taken up into the blood, or act upon the poiſon in the part, and produce their beneficial effects by eliminating and deſtroying the ſenſible qualities thoſe poiſons contain. So totally defective, however, is the Brunonian ſyſtem, that it does not provide at all for the ſpe-

---

ordinate and particular phænomena depend. It is in tracing thoſe phænomena (and which are nothing elſe than effects) from their ſtate of union with their cauſe to their ſeparation from it; from their ſtate of purity and integrity unmixed and undivided, to their imperfect ſtate of diviſion and ſeparation, of weakneſs and diſeaſe, that the inveſtigation of phyſiological ſcience depends, and through which phyſiological knowledge ariſes. The means by which it can be obtained are two: the firſt depends on accurate obſervation of the phænomena of the animated ſyſtem in the healthy ſtate, and its deviation into that of diſeaſe; the ſecond, on experiments, &c. &c.

cific action of ſpecific poiſons: the author, therefore, gets rid of the ſubject thus, p. 63. "The only cure for poiſons is their early diſcharge from the ſyſtem; and if, as often happens, others, by wounding an organ neceſſary to life, are fatal, the effects of both are foreign from our preſent purpoſe, and ought to be referred to local diſeaſes." Aware of the deleterious effects which poiſons produce, he conſequently recommends their early diſcharge from the ſyſtem: he, notwithſtanding this acknowledgment, ſays, "*that it is excitement alone through its varying degrees, that produces either health, diſeaſe or recovery; it alone governs both univerſal and local diſeaſes, neither of which ever ariſe from faults in the ſolids or fluids, but always either from increaſed or diminiſhed excitement: hence the cure is never to be directed to the ſtate of the ſolids or fluids, but only to the diminution or the increaſe of excitement.*" Page 50.

Thus, then, has Dr. Brown, with one ſtroke of his pen, deſtroyed the diſtinction that the wiſeſt and beſt Phyſiologiſts have ever made, of diſeaſes that were merely accompanied by an increaſe or decreaſe of the action, either of particular parts, or of the ſyſtem altogether, from thoſe that were accompanied, not merely by an action too high or too low, but where the action was totally altered from the healthy ſtate, conſtituting a certain peculiarity in the nature of the diſeaſe itſelf, known by the appellation of *ſpecific.* Theſe ſpecific diſeaſes evidently ariſe from the ſpecific quality and active powers of the poiſon, and the weakneſs of the ſyſtem in reſiſting their operation. When theſe poiſons therefore produce their effects upon the ſyſtem, ſometimes deſtroying its action in a few hours, or in a few moments, they ought, in ſuch caſes, to be called *ſedatives.* Shall it be denied, when the ſtrongeſt men are ſuddenly deſtroyed by the inhalation of a few draughts of mephitic gas, that the operation of it is not directly ſedative? When the poiſon of the ticunas, of lauro-ceraſus, and eſpecially of different ſerpents, which Dr. Ruſſel, in his late moſt ſplendid work, has decidedly proved, deſtroy different animals in twenty or thirty minutes, without producing, in many inſtances, any ſenſible action from the time the poiſon is received, to the diſſolution of the animal—ſhall it be pretended that death is not produced by a ſedative effect upon the ſyſtem? It required the arrogance of Dr. Brown himſelf to deny the exiſtence of ſedatives,—to deny the ſpecific mode of their operation, to deny the ſpecific nature of the diſeaſe they produce, or that the matter which is in conſequence evolved, is capable of producing the ſame poiſon upon another ſubject. Thus it is we have the poiſon of plague producing plague, but not ſmall-pox; the poiſon of ſmall-pox producing ſmall-pox, but not meaſles; the poiſon of the itch producing the itch, but not ſyphilis. But, according to the Brunonian ſyſtem, all theſe ſubſtances are one and the ſame in their nature: the only difference there is between them, conſiſts in the different degrees of ſtimulant properties they poſſeſs, and in the different proportion of excitement they produce; ſo that the pox and the itch, typhus fever, and the plague, &c. &c. may be cured by the ſame means, the nature of the ſtimulus alone varying in degree. It might indeed be further ſtated, that the cauſe producing the diſeaſe, and the medicine effecting the cure, are according to him, in their nature, one and the ſame; the only difference between them conſiſting in the degree of ſtimulating power they ſeverally poſſeſs. Hence he ſays, that " whether the matter of contagion act by a ſtimulant or a debilitating operation, *its operation is the ſame with that of the ordinary power*, that is to ſay, the cauſe of diſeaſe is the ſame; and if, as ſometimes happens, no general affection follows the application of contagion; if no undue exceſs or defect of excitement is the conſequence, the affection is altogether local, and foreign to this place*." So far from the aſſertion being true, that the operation of morbid poiſons on the ſyſtem ariſes from the ſtimulus they produce, being merely in exceſs or defect; and that the effect produced on the ſyſtem is the ſame in kind as the nature of the cauſe, whether it be above or below par; ſo that an high ſtimulus ſhall produce increaſed excitement, and a low ſtimulus a weak degree of it, it is often totally otherwiſe.

If this were the caſe, the atonic ſymptoms, in atonic diſeaſes, ought to manifeſt themſelves more eminently after the poiſon has been applied; at the time when it was in the plenitude of its power, acting upon the excitability in the aggregate, without abatement or diviſion, than it is found to do at the latter period of the diſeaſe. If this were true, the ſymptoms of debility, of putrefaction, and of death itſelf, ought to manifeſt themſelves as ſoon as this imperfect ſtimulus is received. Theſe atonic ſymptoms ought progreſſively to go off, in proportion as the effects are abated by the introduction of adequate ſtimuli, and the poiſon itſelf weakened by diviſion and ſeparation. If this were the caſe, typhus fever would invariably begin with ſymptoms of putrefaction, and terminate with thoſe of inflammation; inſtead of the diſeaſe beginning, as it frequently does, with ſymptoms of inflammation, and terminating with thoſe of putrefaction. It certainly is within the knowledge of moſt practitioners, that ſome of the worſt ſpecies of typhus frequently come on with ſymptoms of ſtrong and increaſed action, which demand a ſtrict antiphlogiſtic diet: any other regimen only tends to hurry on the ſymptoms of inflammation, to induce local determinations, either to the head, in producing phrenitis; to the lungs, in producing peripneumonia; or to the inteſtines eſpecially, in producing enteritis. It is only at the latter period of the fever, that the real typhus ſymptoms manifeſt themſelves, when one and the ſame poiſon which produced inflammation at firſt, is the remote cauſe of inducing at laſt the ſtate of putrefaction.

---

* Page 61.

The beſt practitioners that have written on the plague, recommend bleeding and early evacuation as the moſt effectual means of cure; and it is now found, by the general teſtimony of the French phyſicians who have long reſided in the Weſt Indies, and by our own ſurgeons at this time, that if bleeding and evacuations are immediately employed on the very firſt onſet of the yellow fever, the patient generally recovers; and it is found that the adminiſtration of mercury itſelf, ſo as to produce ptyaliſm, ſeems to have almoſt a ſpecific effect in operating a cure. To expatiate on the calamities which this pernicious Brunonian doctrine has produced in its application to practice, will not ſatisfy the humanity it has offended: it will not reſtore the children to the parent, the parent to his children, and a multitude of brave and deſerving ſubjects to their country; thouſands, and tens of thouſands, have fallen victims to it. The yellow fever, in the Weſt Indies, amongſt the Engliſh, was called by the native French ſurgeons the brandy and madeira fever, from the quantity of ſpirituous liquors that were adminiſtered. Whilſt our brave ſoldiers uniformly died by this mode, the French, by adopting the antiphlogiſtic plan in the ſtricteſt poſſible degree, generally recovered *.

Equally falſe are his opinions with reſpect to the different ſtates of excitement that often exiſt in different parts of the ſame ſyſtem: it is notorious to every man of common obſervation, that enteritis and phrenitis frequently

---

* It is proper to obſerve, that I received a particular account of the diſeaſe from a moſt reſpectable and ingenious French gentleman, at St. Domingo, at the commencement of the war, when it was beginning to make ravages amongſt our troops. In this letter he pointed out the cauſes, not only by which the diſeaſe was produced, but the reaſon why it proved fatal; he further gave me the mode which the French, natives of the colonies, uſed to adopt in the treatment of it with univerſal ſucceſs. I thought this letter of ſo much importance, that, after ſhewing it to ſome of my medical friends, I was adviſed to tranſmit it to the Preſident of the Medical Board, *a Fellow of the College* of Phyſicians. He never had the politeneſs to give it any anſwer, not even to acknowledge the receipt of it, although it was delivered to him by one of the moſt eminent Fellows of the College.

ly come on, and are attendant on typhus fever; and the author of theſe pages can ſay with confidence and truth, that he has been the means of ſaving the life of ſeveral patients, by taking blood from the temporal artery, at a time when there was a brown tongue, a quick pulſe, and the other ſymptoms of low fever. On the contrary, Dr. Brown thought, page 44, "that every affection of a part, that occurs in general diſeaſes, however formidable, is to be conſidered only as a part of the affection inherent in the whole body, and the remedies are not to be directed to a part, as if the whole diſeaſe lurked there, and was only to be removed thence; but to the whole body, all which it affects *."

---

* It is unneceſſary for me to extend any further my obſervation upon the Brunonian practice, which is held up as the model of perfection in the univerſity where Brown himſelf was at firſt perſecuted by thoſe who have in ſome meaſure adopted its tenets. Of that practice, which is the prevailing one at this time at moſt foreign univerſities, and which is promulgated in London itſelf by many teachers, although in a more indirect way; I ſhall merely confine myſelf to point out the ignorance or want of knowledge neceſſary to put it in force. "Such is the ſimplicity, ſays Dr. B. to which medicine is thus reduced, that when a phyſician comes to the bed-ſide of a patient, he has only three things to ſettle in his mind: 1ſt, whether the diſeaſe be general or local: 2dly, if general, whe-

ther it be ſthenic or aſthenic: 3dly, what is its degree. When once he has ſatisfied himſelf in theſe points, all that remains for him to do, is to form the indication or general view of the plan of cure, and carry that into execution by the adminiſtration of proper remedies.

The only thing of importance with reſpect to diagnoſis, is that by which general diſeaſes are diſtinguiſhed from thoſe local or ſymptomatic affections, which, by throwing the whole ſyſtem into diſorder, aſſume a certain reſemblance to univerſal diſeaſes. In order to attain this uſeful knowledge, he recommends us to waſte no time in ſuperfluous ſtudy of anatomy, but to learn only what is neceſſary from it. We are to peruſe the works of Morgagni; to diſſect ſubjects; to diſtinguiſh reſiduary effects from cauſes that have paſſed away; to examine diligently many bodies of perſons who have been hanged or have died of wounds, but were otherwiſe healthy; compare theſe diligently with the bodies of thoſe who have died of lingering, or often repeated diſeaſes; compare every particular with every other; the whole with the whole.—Notwithſtanding theſe recommendations, which are certainly wiſe in themſelves, and which include the only means by which our knowledge is to be attained, he tells us that we muſt never expect to diſcover the cauſe of general diſeaſe in dead bodies; and, finally, to beware of raſh hypotheſes; and to be circumſpect in forming a judgment!!! Page 72.

Conſcious as I feel that this doctrine is defective and diſeaſed; that it is founded on error, and leads to miſchief, I have thought it my duty to point out a few only of its errors. I ſhall now proceed with the more immediate object of this work, to ſhew the various means which the animated ſyſtem poſſeſſes, to reſtore the waſte it perpetually ſuſtains in conſequence of the actions it performs, and the mode by which the end is ultimately attained.

CHAP. III.

ON THE BLOOD.

The colour varies in different ſyſtems, is more florid and red in the higher than in the lower order, generally white in the inſect tribe, as alſo the medulla in vegetables—the degree of union that exiſts between different parts of blood varies conſiderably—the red parts conſtantly diſpoſed to become ſolid, and to coagulate the fluid—coagulation produced by the action of chemical bodies—the blood has no power of action in itſelf, contrary to Mr. Hunter's opinion—the relation which the blood bears to the organs and veſſels—the vitality of the blood proved, &c. &c. &c.

WHEN we behold the evolution which the animated ſyſtem undergoes from the fœtal to the adult ſtate, and the waſte it perpetually ſuſtains in conſequence of the various operations it performs, the neceſſity of a proper ſupply of blood muſt be apparent, not only in order that the living principle may unfold itſelf, but that it may be able alſo to preſerve the organization which it has unfolded. The conſumption which the blood ſuſtains in the fœtal ſtate, when there is evolution in general, with little or no ſpecific action, muſt be leſs in degree than in the adult, when there are evolution and ſpecific action together.

It is by comparing the ſenſible properties of the blood in different ſyſtems, and in different ſyſtems of veſſels, at different and oppoſite periods of life, that we are led to underſtand the cauſes of the variety in the appearance it aſſumes.

If we examine the colour it aſſumes, as we proceed from the higher to the lower order of animated beings, we ſhall find that there is not only a great degree of difference in the caſt which the red parts exhibit, but in the relative proportion which they bear to the other parts. The blood of the human ſpecies, and of quadrupeds in general, is of a florid colour, often bordering upon a purpliſh caſt. The blood of the amphibia and of fiſh is leſs dark, but more florid and red: the blood of inſects, in ſome inſtances indeed, is yellow; in others it is green, as in the caterpillar; but it is commonly of a white and ſerous colour: and, finally, the medulla of plants is, generally ſpeaking, of a white flowery appearance.

The red parts of the blood have generally received the appellation of cruor or craſſamentum: the white parts have generally been divided into two, and conſidered as ſeparate and diſtinct, namely, the coagulable lymph and ſerum. The coagulable lymph has been ſuppoſed to conſtitute the portion of the blood which was eſpecially employed for the ſupport of the whole ſyſtem; whilſt, on the contrary, the ſerum, by virtue of its fluidity, has been thought to be uſeful in keeping the different parts of the blood, as it were, in a diluted form.

If we examine theſe parts ſeparately, we ſhall find that there is a conſiderable variety in the degree of union that exiſts between the different parts of which the maſs of blood is compoſed. In the ſerum, the union is more perfect than it is in the coagulable lymph; in the coagulable lymph, than it is in the red parts. Such, indeed, is the ſeparation that ſubſiſts in the red parts, that they are evidently of a globular form: inſtead of being in union with the whole, there is a marked and diſtinct ſeparation between them and the other parts. The red parts are congregated together into globules, ſwimming as it were in the ſerum, which is apparently homogeneous in its nature, and altogether united. The red globules in the ſerum, with reſpect to figure, reſemble particles of oil immerſed in water; and the ſerum, with reſpect to the red globules, reſembles water having involved in it particles of oil: theſe red globules appear to me to conſtitute the refuſe of the whole maſs; having a conſtant tendency themſelves to coagulate, they perpetually diſpoſe the coagulation of the ſerum alſo: it ſeems to be owing to the ſenſible qualities which theſe red globules poſſeſs, that the ſerum in which they are involved becomes perpetually changed from a fluid to a ſolid ſtate. One of theſe red particles becomes coated as it were with a proportion of fluid ſerum; accretion progreſſively enſues, and globules are ultimately produced.

Such is the tendency which the red globules poſſeſs to become ſolid, that the change takes place in a few minutes after extravaſation, and the ſerum itſelf, in which theſe particles are involved, becomes ſolid alſo *. It appears, indeed,

---

* Theſe red particles are ſoluble in water, imparting, however, a colouring matter to the water after they have been diſſolved by it: they are partly ſoluble in vinegar, and in lemon juice. When the ſerum itſelf is diluted with

indeed, that theſe red particles are in their nature ſolid, that they coagulate the ſerum by which they are immediately ſurrounded, and conſtitute the connecting medium of what is called the craſſamentum. On the contrary, the ſerum, which is in ſome degree removed from the influence of theſe red globules, inſtead of becoming coagulated, preſerves its fluidity. If we examine the tendency which the red globules poſſeſs to coagulate the ſerum, and the various other means by which ſerum itſelf may be coagulated, we ſhall be led to conclude, that when the red globules coagulate the ſerum, it ariſes from the deprivation of the preſervative property it poſſeſſes; and that the change it undergoes from a fluid to a ſolid ſtate, is a change from a good to a bad condition.

Blood, whether red or white, or both, may be coagulated by expoſure to the operation of external cauſes; it coagulates ſooner when

with water, they are ſoluble alſo in it. It is the ſame with urine. On the contrary, inſtead of being ſoluble by other ſubſtances, they are particularly coagulated by them; as the muriatic, nitric and nitrous acids. Neither are they ſoluble in a ſolution of marine ſalt, or fixed vegetable alkali.

drawn into a baſon having a large ſurface, than a ſmall one; when drawn ſlowly, than rapidly. The reaſon is this: the extraneous matter of which that large ſurface is compoſed, acts more extenſively upon the blood; and the ſlowneſs of its tranſition from the blood-veſſel to the baſon, expoſes it to the more ready action of the air, the operation of which it cannot reſiſt: it therefore loſes its fluid ſtate, which it cannot preſerve, and obtains a ſolid form, which it cannot prevent. On the contrary, when blood ſubſiſts in a moving ſtate in the veſſels of a living animal, inſtead of coagulating, it preſerves its fluidity for an indefinite period. If, however, it be extravaſated in the ſyſtem, ſuch is the tendency which it poſſeſſes to coagulate, that it generally undergoes this change; ſooner if it be extravaſated in a dead part than in a living one*: it coagulates ſooner if it be extravaſated on an expoſed ſurface, than in a circumſcribed cavity; on an open canal, than in the cellular membrane.

---

* A perſon was ſeized with a mortification of the foot and leg, and which had advanced to a conſiderable extent. The perſon died. On examining the part above the mortified portion, Mr. Hunter found the crural and iliac arteries completely filled with ſtrong coagulated blood. On the contrary, he found the blood of a fiſh which had the action of life ſuſpended for three days, and was ſuppoſed dead, had

If we extend our view to the various means by which blood may be coagulated out of the body, we ſhall find them reducible to ſuch as overcome the reſiſting power of the ſolids, producing in them either weakneſs or death itſelf; viz. expoſure to exceſſive degrees of heat; combination with the cauſtic alkali, with acids, with alcohol, &c. &c. Theſe powerful chemical bodies act by depriving the blood of the preſervative property it originally poſſeſſed; it therefore becomes converted from a fluid to a ſolid, from a living to a dying ſtate.

The cauſe I aſſign for the blood coagulating, is certainly very different from what Mr. Hunter entertained. Mr. Hunter ſuppoſed that the coagulation of the blood aroſe from an exertion of the living power which it contained, ſimilar to the contraction of a muſcle; and that it poſſeſſed the power of action within itſelf. Mr. H. ſays, " that the blood coagulates from an impreſſion; that is, its fluidity, under ſuch

---

had not coagulated in the veſſels; but on being expoſed or extravaſated, it ſoon coagulated.

circumſtances, being improper, or no longer neceſſary, it coagulates to anſwer now the neceſſary purpoſe of ſolidity." Again, "If the blood could only have been of uſe in a fluid ſtate, its ſolidity would not have been ſo much an object with nature. It appears to me to be evident, that its fluidity is only intended for its motion, and its motion is only to convey life and living materials to every part of the body. Theſe materials, when carried, become ſolid, ſo that ſolidity is the ultimate end of the blood, as blood *."

It is readily admitted, that a fluid condition of the blood is neceſſary to the motion of it; but I conceive it far, very far indeed, from truth, that ſolidity is the ultimate end of the blood, as blood. It is the moſt fluid parts of the whole that are eſpecially employed in the reſtoration of parts, and that are conveyed to glands for the purpoſe of their action: they are conveyed to theſe organs in a fluid, not in a ſolid form: they are converted by them from this fluid form, according to the eſpecial nature of each. The object, however, which Mr. Hunter has in view, is to eſtabliſh the

---

* Page 72.

power of action in the blood itſelf. I have reaſon to believe, ſays he, " that the coagulum has the power of action, under neceſſary circumſtances, to form veſſels in and of itſelf. For, although the coagulation is not organic, it is ſtill of a peculiar form, ſtructure or arrangement, ſo as to take on a neceſſary action, which, I ſhould ſuppoſe, is ſomewhat ſimilar to muſcular action. I think I have been able to inject what I ſuſpected to be the beginning of a vaſcular formation in a coagulum, when it could not derive any veſſels from the ſurrounding parts. And again, I have reaſon to believe, that the blood has the power of action within itſelf, according to the ſtimulus of neceſſity, which neceſſity ariſes out of its ſituation."

I ſhould certainly overlook this paſſage on account of its obſcurity, did I not know that it conſtitutes the baſis of Mr. Hunter's opinion on this important ſubject. So far, however, from the coagulation of the blood being an operation of life when it ariſes ſpontaneouſly, it proceeds from a diminution or deprivation of life; it is an act of dying, or of death itſelf. It is by comparing the condition of the blood when moving in the veſſels of a living animal, and taking that condition as the ſtandard of its perfection, that we are to judge of the various morbid changes which it undergoes. It is thus we find that blood, in its moſt perfect, is in a fluid ſtate, in union and in motion; in its moſt imperfect ſtate, it is decompoſed into a ſolid and fluid form, and is at reſt. The parts that are *ſolid*, conſtitute the refuſe of the whole; they form thoſe parts that are never employed for the purpoſe of reſtoration or of ſecretion. On the contrary, the parts which continue fluid are thoſe which are eſpecially employed for the purpoſe of reſtoration and of ſecretion alſo. This fluid portion, however, cannot always preſerve its fluidity when expoſed to the action of external cauſes; it loſes this preſervative power alſo; it becomes acted upon, and converted from a fluid to a ſolid ſtate; in conſiſtency it becomes like the coagulated lymph or ſolid craſſamentum, and the whole is changed from the real nature of blood. The action that takes place (the change, it ought to have been ſaid) does not ariſe from any power of the blood within itſelf which it contains: it proceeds from a loſs of power; it does not change itſelf, but it becomes changed, whether by acids or alkalis,

kalis, by high degrees of heat, and more eſpecially by the conſtant tendency to which it is prone, and which it ſpontaneouſly undergoes, conſtituting its diſeaſe and death.

If the coagulation of the blood aroſe from the power of action within itſelf ſimilar to muſcular contraction, coagulated blood might reſolve itſelf into a fluid form, by virtue of its own power, ſimilar to the relaxation of a muſcle. It is far otherwiſe: when blood is extravaſated out of the veſſels, the firſt change which it generally undergoes, is a ſeparation into parts; into craſſamentum, which coagulates; and into ſerum, which remains fluid. Although this fluid ſerum may be coagulated and made ſolid, ſolid ſerum or coagulated lymph cannot be reſolved back again, of itſelf, into a fluid form; that is to ſay, it may be changed from a good and a healthy ſtate, to a bad and a diſeaſed one; but it cannot be meliorated from this bad into a good ſtate, without the operation of the organ by which it was formed, and on which its perfection depends.

If all the parts of the blood poſſeſſed their preſervative powers in an equal degree, the whole would remain in a fluid homogeneous ſtate out of the body, as we behold it moving within it: if it ſeparated into parts, inſtead of ſeparating at different intervals, it would ſeparate at one and the ſame time. It is far otherwiſe: ſuch is the plenitude of life which the ſerum contains, that it retains its tranſparent colour and ſweetneſs for a conſiderable time. On the contrary, it is owing to the paucity of living power which the craſſamentum poſſeſſes, that its preſervative powers are ſo ſoon loſt, that it emits a quantity of gazeous matter, and becomes putrid. Wiſhing to aſcertain the relative power of preſervation between both, I took four ounces of ſerum, and four ounces of the craſſamentum, from the ſame perſon, after the ſeparation had taken place, at a time when the thermometer was at 60. In four days the craſſamentum gave out a quantity of fœtid vapours, and in ſix days was completely putrid. On the contrary, the ſerum preſerved its ſweetneſs and homogeneous nature for ſeventeen days. It then began to become ropy or coagulate; to give out vapours alſo; and in three days more it was offenſive to the ſmell. I took eight ounces of blood, and prevented the ſeparation of it into parts, by agitating the whole together until a coagulum was formed. I found its preſervative power neither ſo ſtrong as the pure ſerum, nor ſo weak as the craſſamentum; but a medium as it were between both; it became very offenſive to the ſmell in twelve days.

I expoſed the ſerum and craſſamentum ſeparately to the action of the different acids; the ſerum, I found, was immediately coagulated, and became like the albumen ovi. On the contrary, the craſſamentum became decompoſed; a number of very offenſive vapours were extricated, and the reſiduary matter formed a ſolid ſubſtance of a carbonaceous colour. The ſame effects took place by expoſure to heat; the craſſamentum became ſolid at a very low degree of heat. On the contrary, it requires 153 degrees for the coagulation of the ſerum. There are, however, two ſmall proportions of the ſerum that do not ſeem to be ſuſceptible of this act: one part is called by *Senac* the ſeroſity of the blood, and another part that goes off in the form of vapour. I have frequently watched the ſeparation which the blood undergoes, from the time it was obtained, and I think it very probable that the ſeparation of this volatile matter favours the ſolidity which is induced. It is a fact, that the coagulation of the blood is accelerated by expoſure to heat, when this evaporation is increaſed; and, on the contrary, that expoſure to cold rather retards coagulation; ſo that when blood is drawn into a baſon and immediately frozen, if it be thawed again, it is found to recover its fluidity alſo; but if this ſame blood be again expoſed to heat, and the evaporation of its moſt ſubtle parts induced; coagulation enſues, without any power of its own to reſolve itſelf back into a fluid form.

After blood is diſcharged from the ſyſtem into a veſſel, it either ſeparates into parts, or coagulates altogether. Coagulation is the firſt change induced by the action of external cauſes upon the worſt part of the whole, and the ſeparation that takes place would ſeem to ariſe from the different degrees of living power each part reſpectively contains. In ſtrong conſtitutions in a healthy ſtate, or even in weak conſtitutions that are attacked with inflammatory diſeaſes, when the actions of life are particularly exerted, a ſeparation very often takes place; a large proportion of ſerum is found to ſubſiſt, and a ſmall one of craſſamentum; and the craſſamentum itſelf is very compact and ſolid. On the contrary, in weak conſtitutions, and more eſpecially if attacked with atonic diſeaſes, little or no ſeparation enſues, the whole either coagulates, or the red parts continue diffuſed with the ſerous, forming an opake gelatinous maſs.

Mr. Hunter ſays, "that blood coagulates ſooner in vacuo than in the open air." The reaſon is obvious: in the act of exhauſting the air which the receiver contains, a quantity of the moſt volatile part of the blood itſelf is evaporated alſo; and thus it is that the decompoſition which is produced, accelerates the coagulation of the reſt.

He is alſo of opinion, "that the fluid ſtate of the blood is connected with the living veſſel which is its natural ſituation, and with motion; and that when there is a full power of life, the veſſels are capable of keeping the blood in a fluid ſtate: a total ſtagnation of the blood, as in a trance, or when the circulation has been ſtopped for ſeveral hours, as in the caſe of a perſon apparently drowned, does not make it coagulate; and yet when there are no actions going on in a part, if the blood ſtagnates for a much ſhorter time, it will be found coagulated, as in mortification: but then the coagulation is to anſwer a good purpoſe, and ariſes from neceſſity, which appears to act as a ſtimulus in diſpoſing the blood to coagulate."

There can be no doubt, but that a proper harmony does ſubſiſt between the veſſels and the blood they contain; and that ſo long as the veſſels poſſeſs the full power of life, they retain the power of keeping the blood in motion and in a fluid ſtate, and that this ſtate of fluidity and of motion is the natural condition of the blood: although it is very true, that in a trance, and in ſome caſes of ſuſpended animation, the blood does not move, and yet is found to continue in a fluid form. On the contrary, in caſes of mortification, where the actions of life, inſtead of being ſuſpended, are irretrievably loſt, coagulation immediately enſues; it enſues in a period much ſhorter than if the actions of life were merely ſuſpended. This I take to be a true paraphraſe of Mr. Hunter's opinion, and which appears to me to lead to concluſions diametrically oppoſite to thoſe he has drawn.

" The coagulation which takes place in mortification is to anſwer a good purpoſe, and ariſes from neceſſity, which [neceſſity, I ſuppoſe] appears to act as a ſtimulus in diſpoſing the blood to coagulate." The very circumſtance itſelf, of coagulation taking place in mortification, ſhews, that it does not coagulate from any action of its own, having ſome good purpoſe in view; but, on the contrary, that it coagulates from neceſſity, becauſe it cannot preſerve its fluid ſtate. In the ſame manner as a man that dies, he dies from neceſſity alſo, becauſe he cannot preſerve himſelf in a living ſtate. There certainly is no ground whatever to conclude with Mr. Hunter, that " the coagulation of the blood ariſes from a living power in the blood, influenced, in ſome degree, in a way ſimilar to muſcular action. That it is an action of life, proceeding exactly upon the ſame principle as the union by the firſt intention." Page 28.

The colouring part of the blood is far leſs conſiderable than is generally imagined, and conſtitutes the worſt part of the whole. The lower order of animals, whoſe living powers are moſt ſtrong, are nearly, if not altogether, deſtitute of it; and, in the higher order of animals, it is never employed for the formation and reſtoration of parts. Its preſervative powers are weak, whilſt thoſe of the ſerum are ſtrong: the one putrefies ſoon, the other continues ſweet long. I have known it continue in an apparently healthy ſtate, when effuſed in the cavity of the thorax,-abdomen, or tunica vaginalis, for months and years, in dropſies of thoſe parts; although it ſoon decompoſes and becomes putrid, after being diſcharged by expoſure to the action of the air. We muſt therefore conſider the ſerum and coagulable lymph of the blood as the moſt vital parts of the whole, which contain the general life common to the whole, the materia vitæ diffuſa; but differing from the ſeveral parts of the ſyſtem in being deſtitute of all power of ſpecific action.

The different organs of which the ſyſtem is compoſed not only poſſeſs in common with the blood the general life of the animal, but they have connected with it the ſpecific power alſo, the materia vitæ coacervata; whereas blood poſſeſſes the general life only, but is totally deſtitute of any ſpecific power.

It is this general life which is diffuſed throughout the whole of the ſyſtem, that is the cauſe of the unity and totality that prevails in every one ſyſtem; why no part of the ſyſtem is diſtinct from the whole, and why one ſyſtem is ſeparate and diſtinct from the common matter by which it is ſurrounded. But it is the *ſpecific power* which the different organs poſſeſs, that conſtitutes the means by which the various phænomena of life are diſplayed, and why one ſyſtem is different from another in the different actions they perform.

The Relation which the Blood bears to the Organs.

The parts of the blood which contain the general life of the ſyſtem in the moſt eminent degree, with the leaſt proportion of ſenſible properties, are thoſe that are beſt fitted to be acted upon, and converted by the different organs to which they are applied. It cannot be the red parts, becauſe the ſenſible qualities they poſſeſs of colour and of figure muſt diſqualify them to receive the impreſſion from the organs; and the tendency theſe parts poſſeſs to diſſolution, renders them unfit to become ſubſervient to the reſtoration of living parts. On the contrary, when we reflect on the properties of the ſerum and coagulable lymph, it muſt evidently appear that thoſe parts are eminently qualified to be acted upon and converted; they are not only deſtitute of all ſenſible qualities, whether of colour or of figure, but the high degree of preſervative property they poſſeſs, fits and adapts them in a moſt eminent degree to form the ſubject matter out of which the different parts of the ſyſtem are conſtituted and renewed, and the various ſecretions produced. This portion therefore of the blood is colourleſs, inodorous, and fluid, poſſeſſing all aptitude in general, and no ſenſible quality: by virtue of its living principle, it ſubſiſts in perfect harmony with the veſſel by which it is contained. It may be called therefore the primary matter with reſpect to the organs. It is with a view to preſerve this aptitude in the blood, and to prevent the ſenſible qualities which the red parts contain, from being employed or exerting any influence upon the organs, that we behold the final cauſe for the exhalant termination of the arteries into capillary tubes, by means of which a mechanical cauſe exiſts, to prevent a mechanical evil. If it were not for this mode of conſtruction, if the exhalant termination of the veſſels were large inſtead of ſmall, not only the ſerous but the globular parts of the blood would be permitted to flow through ;—thoſe parts of the whole that poſſeſs quality without aptitude, that would act upon the organs, inſtead of poſſeſſing the fitneſs to be acted upon by them. There is therefore a gradual diminution in the ſize of the veſſels, that the contents which they diſcharge may be of the moſt pure and of the moſt living kind ; by its living property, that it may be fitted to reſtore the loſs which the ſyſtem ſuſtains ; and by its tenuity, that it may be accommodated to the power of the part in which it is depoſited. It is therefore propelled without reſiſting, and follows the impulſe it receives from the veſſels in which it is contained.

Beholding as we do a difference of colour in different parts of the ſyſtem, of different parts endued with apparently the ſame conſtruction, it is probable that the termination of the veſſels varies in a conſiderable degree; as there are ſome muſcles that are almoſt white, and others again are perfectly red. The blood is diſtributed to the different parts of the ſyſtem for their renovation and ſupport, and to the various glands of the body, by whoſe power it is changed, and from whence their ſeveral fluids are formed.

It is in this point of view that blood is to be conſidered with reſpect to the organs; the one poſſeſſing all aptitude to be acted upon, and no power of acting; the other poſſeſſing all power of acting, but no aptitude to be acted upon. Blood bears the ſame relation to the power which the organs ſeverally poſſeſs, that brick and mortar do to the architect and to the artiſt, out of which a building is erected. Blood has no more the power to convert itſelf into any particular organ, than brick and mortar have of themſelves the power to form a building. Blood conſtitutes the materials only; the living power of the part in which it is depoſited, conſtitutes the architect by which it is faſhioned and changed—by the liver into bile—by the pancreas into pancreatic juice—by the teſtis into ſemen, &c. &c. It is therefore the organs that act, and the blood which is acted upon: whilſt the former are active, the other is paſſive: a mere tabula raſa alone. On the contrary, if the blood poſſeſſed any power of action within itſelf, by virtue of the ſenſible properties it contains; if it had the power of converting itſelf, by itſelf, either into different organs or into different fluids, no neceſſity could ſubſiſt for the exiſtence of glands, ſince the proceſs of converſion and of ſecretion could take place without their influence. We might as well ſuppoſe that a building can be erected without hands, and deſigned without a deſigner: it is to ſuppoſe an effect produced without a producing cauſe, or at leaſt that the effect and the cauſe are one and the ſame; a doctrine fanciful and falſe, which never has ſubſiſted and never can ſubſiſt.

If the different ſecretory organs were alike formed, and the blood that flowed into them the ſame in all, there could be only one kind of ſecretion. Seeing however, as we do, that the blood is apparently the ſame, and that the organs are in their conſtruction totally different, we muſt neceſſarily conclude, that the variety we behold in the nature of the ſecretions produced, depends on the power of the organs, and the peculiarity of their fabric, and not on the power of the blood. If the blood were the agent in the office of ſecretion, we ſhould be led to expect that the quality of the ſecretions would depend on the nature of the part from whence the blood was derived. It is far otherwiſe: we frequently behold an irregularity in the origin of the arteries which ſupply particular parts, although the matter to which it is afterwards converted is the ſame. For example: the ſpermatic arteries ſometimes ariſe from the emulgent, inſtead of the iliacs, and the emulgents themſelves from the ſpermatics. If the blood, therefore, had any power in the office of ſecretion, inſtead of the glands, we ought to ſee the teſtes ſecreting urine inſtead of ſemen, and the kidneys ſecreting ſemen inſtead of urine. A ſubject fell to Mr. Abernethy's lot for diſſection, in which the liver, inſtead of being ſupplied with blood for its ſecretory office from the vena porta, was ſupplied by many arteries with arterial blood, and yet the bile did not ſeem eſſentially different from what it is uſually found. If blood had the thepower of acting upon glands, it could not conſtitute the mere ſubject matter that was acted upon by them. Inſtead of being depoſited into them by exhalant outlets, it would be poured out from open canals; inſtead of being converted by the organs, it would convert the organs to its own nature; inſtead of harmony ſubſiſting between the parts, there would be perpetual warfare in the whole.

If theſe ideas were true, the blood would indeed be what Mr. Hunter ſuppoſed: it would be an animal within an animal, an animal that fed and preyed on the ſolids, by the power of which it was produced, and to which it is deſtined to be ſubſervient: inſtead of the ſolids feeding on the blood, it would be the blood feeding on the ſolids. We ought therefore rather to conclude, that the organ is the part that acts, and the blood is the ſubject matter which is acted upon.

For ſecretion therefore to take place, there muſt ſubſiſt the co-operation of two cauſes—power in the organ, and aptitude in the blood as the ſubject matter: it is the organ that imparts, ſimilar to the impreſſion engraved on the ſeal; it is the blood that receives the impreſſion

ſion from the organ, ſimilar to the wax from the quality of the ſeal *.

It is by this relation of power in the organs, and aptitude only in the blood, that the whole proceſſes are effected of ſecretion and of growth: it is by the energy of the living principle which the fœtus exerts on the blood it receives, that evolution is produced, and not from any active powers in the blood. If the ovum were removed, in which the fœtus is involved, and the ſame blood were applied to the uterus, a coagulum, a rudis indigeſtaque moles would be formed, perpetually verging to coagulation and to putrefaction. On the contrary, when the blood is applied to the living power of the embryo, it becomes modelled and organized, tending to action, and poſſeſſing the power of preſervation. It is by the ſame proceſs that the acorn becomes evolved into an oak, out of matter paſſive and formleſs, and in ſhort the whole of animated creation †.

It

---

* It is very probable that the exhalant outlets of the arteries, which terminate in glands, are differently conſtructed, in order that the quality of the blood may be properly adapted to the ſeveral natures of each.

† It is a matter that ought to be ever preſent to the mind, that the cauſe of vitality had a ſubſiſtence prior to

the

It is by aſcertaining the nature of the blood in the aggregate and in its parts, when it ſubſiſts in its moſt perfect and imperfect ſtate, and by comparing one ſtate with the other, that we are able to know whether coagulation of the blood can ariſe from an action of its own, and whether that action proceeds from an effect of the living principle it contains. Can it be pretended by the ſupporters of Mr. Hunter's opinion, that the craſſamentum is more alive by remaining ſome time out of the ſyſtem, when it is expoſed to the operation of thoſe cauſes that produce its death, than it was when moving in a fluid form in a living animal? As ſoon as it is diſcharged from the veſſels of a

---

the organization; the organization itſelf, a ſubſiſtence prior to the ſubject matter on which it operates. For example: the ſtomach before the food; the tongue before ſapid bodies; the noſe before thoſe that poſſeſs flavour. It is the greateſt error that can be conceived, in thoſe that ſuppoſe that there is any ſuch thing *abſolutely* exiſting in nature, as flavour, or taſte, or ſound, &c. It is owing to the relation which theſe ſubſtances bear to animated beings, that we ſay, ſuch and ſuch things are articles of food—of food to what? To the ſtomach. Without the ſtomach, the cabbage is a mere vegetable ſyſtem only; but it becomes food when applied to the digeſtive organs of any animal—and ſo on of the reſt.

living animal, it generally ſeparates, and aſſumes a fluid and a ſolid form, or becomes altogether ſolid, as we behold in the veſſels after the actions of life have ceaſed. If it be true, as it is contended, that there does exiſt coagulable lymph ſeparate and diſtinct in its properties from the ſerum, no action of life is neceſſary to make it coagulate, ſince it is ſo already. The actions of life are neceſſary to make it what it is not, that is to ſay, to make this coagulable part of a fluid nature. Beholding however, as we do, that the ſerum may be coagulated, by ſeparation from the living ſyſtem, and more eſpecially by the operation of chemical bodies; I think it more reaſonable to conclude, that the ſeparation which takes place of the ſerum from the craſſamentum, proceeds from the unequal degree of preſervative power contained in each; that the ſerum continues fluid, ſo long as it retains this preſervative property; that it then gradually loſes its fluidity with its life, becomes ſolid, and ultimately dies.

I ſhall briefly relate the hiſtory of a caſe that fell to my care, with a view of ſhewing how ſtrongly diſpoſed the ſerum or coagulable lymph is to coagulate in conſequence of diſeaſe. A man aged twenty-two, originally of a healthy habit, became extremely emaciated, and his conſtitution very much impaired, from a very ſevere courſe of mercury, and neglecting himſelf during that time: he was afterwards ſeized with a violent cough; a copious expectoration of mucus from the ſurface of the bronchia took place, often mixed with ſtreaks of red blood; he generally complained of an acute pain in his cheſt; his pulſe, which had always been very quick, became ſo irregular that it could not be counted.

After theſe ſymptoms had continued a fortnight, ſmall ſolid pieces of coagulating lymph were coughed up in the form of worms. The expulſion of them was always effected by a fit of coughing, leaving behind an exceſſive ſoreneſs in ſome part of the cheſt. In proportion as he became weaker, theſe portions, which were very numerous, progreſſively increaſed in magnitude, and aſſumed a ramified appearance. The ramifications were ſo numerous in many inſtances, that it appears to me they muſt have filled the greateſt number of the bronchia of one of the lobes of the lungs. They were attached to a trunk, which, I ſuppoſe, filled the branch of the trachea after its diviſion. They were perfectly ſolid in their texture, and he was nearly ſuffocated ſeveral times in the act of expectoration. The fits of coughing, however, progreſſively diminiſhed in violence; the man's health, by proper medicine and diet, became reſtored, and he finally recovered altogether *.

Such is the preſervative power of the ſerum, that it continues fluid out of the body, unleſs it be expoſed to 153 degrees of heat; and it requires the active power of chemical ſubſtances to make it undergo the ſame alteration. Will it be pretended, that ſerum coagulated by theſe means proceeds from a living action of theſe dead bodies? Is it not more reaſonable to conclude, that the change it ſuſtains, from its natural fluid ſtate, proceeds from a diminution of living power; and that it is therefore made to aſſume a coagulated form? In diſeaſes, the blood ſeems to undergo, in common with the

---

* This is the ſame caſe which Mr. Hunter has related in his book upon the blood, page 575. in which he has given an engraving of a ſpecimen of the coagulating lymph which I preſented to him, and that by no means the largeſt of the whole.

ſolid parts, very conſiderable alteration; and there are ſome diſeaſes that appear to affect the blood more than the ſolids.

I muſt therefore repeat, that the blood conſtitutes the ſubject matter out of which the different parts of the ſyſtem are formed and renewed; it bears the ſame relation to the organs, as the block does to the ſtatue: if the block were already chiſeled into a ſtatue, the prior exiſtence of that ſtatue would render the marble, whilſt in that condition, unfit for the art of the ſtatuary; but, being a plane alone, it becomes a fit recipient for the figure he purpoſes to engrave.

It is the ſame with blood. Blood poſſeſſes all paſſivity and no power; being all capacity, it becomes fitted to be acted upon, without having the power of acting: if it poſſeſſed any power of acting, it would reſiſt the action of the organs to which it was applied; it would act *upon* them, inſtead of being changed and converted *by* them; it moves, without having any power of moving itſelf; it is propelled, without reſiſting, and follows the impulſe it receives from the veſſels in which it is contained, and by which it is conveyed.

Whenever this relation between the blood and the organs is loſt, a total inverſion of principle exiſts, and diſeaſe enſues. If the blood, which is conveyed to the different parts of the ſyſtem for the reſtoration of the waſte it ſuſtains, preſerves the identity of its nature unaltered and unchanged, no reſtoration of parts can take place. The interſtitial fluid which is effuſed from the exhalant veſſels progreſſively accumulates, and anaſarca follows. Such is the preſervative property which the ſerous or interſtitial fluid poſſeſſes, that it generally continues in a fluid ſtate, ſubſiſting in harmony with the living parts in which it is depoſited *. On the contrary, when inflammation exiſts, the increaſed action which the veſſels ſuſtain, not only forces the moſt fluid parts of the blood, but ſome of the more coagulated and red parts alſo. Blood of this deſcription is totally unfit for the purpoſe of organization. If it continues

---

* This diſeaſe does not ſo much ariſe from a defect of the blood, as from the weakneſs of the ſolid parts, by which they are prevented from organizing the fluid which is applied to them. The ſolid parts, when in a healthy ſtate, act upon the blood preciſely in the ſame manner as the living principle of the embryo did upon the contents of the ovum.

in the part where it is depoſited, it progreſſively loſes its preſervative power; it coagulates, and ultimately aſſumes a purulent appearance. The change that the ſerum alone ſuſtains, when it is depoſited in circumſcribed cavities that are excluded from the influence of the external air, is much ſlower than when it is effuſed from cut ſurfaces, or from canals having an external outlet. The influence of the external air accelerates the proceſs of decompoſition, and makes it change from a ſerous or coagulated ſtate to a purulent one.

The coagulation of the ſerum or coagulable lymph conſtitutes a medium ſtate between the fulneſs of its life when perfectly fluid, and the total privation of it when it becomes purulent and offenſive: in circumſcribed abſceſſes the veſſels contain and diſcharge fluid ſerum before ſerum coagulated, and ſerum coagulated before purulent ſerum or *pus*. Theſe are all different changes the ſame ſubſtances undergo, owing to the different degrees of preſervative properties they contain and loſe *.

---

* I have frequently deſtroyed the preſervative property of ſerum, by expoſure to heat: it coagulates like the albumen

I could illuſtrate this principle by an infinite number of facts; I ſhall however confine myſelf to one. Mrs. D. had an ovarial dropſy, which was tapped at firſt every nine months; the accumulation of ſerum progreſſively increaſed, and it became neceſſary to tap her at ſhorter intervals—from nine to ſix months, from ſix months to four; and ſhe was tapped towards the latter period of her exiſtence every fortnight. She lived ſix years from the time that the firſt operation was performed, to her final diſſolution. For the firſt four or five years her general health continued unimpaired: the ſerum that was diſcharged was perfectly tranſparent and inodorous. When ſhe became weakened and emaciated (and ſhe was naturally of a very ſlender form) the diſcharged fluid diminiſhed in quantity, but increaſed in thickneſs; ſo that, the two or three laſt times that ſhe was tapped, nothing elſe than a ſmall portion of thick gelatinous matter was obtained. On opening her body after death, my worthy friend and partner Mr. Walſhman and I found

---

bumen ovi, and ultimately becomes purulent; and the craſſamentum itſelf is ſo firmly coagulated, that it is perfectly brittle.

that the diſeaſe was ſituated in the right ovarium, which occupied the whole anterior ſurface of the abdomen, extending as high as the diaphragm. It was nearly full of large maſſes of coagulated matter, partly ſerum coagulated, and ſerum purulent, or perfect pus *.

It was a favourite opinion of Mr. Hunter, "that the production of pus depended on a particular action in the veſſels; that it was, in fact, a ſecretion formed from a ſimilar ſtructure of veſſels, as the ſecretion from the blood."

Mr. Home, his nephew, whom I have already mentioned with obligation, made a number of experiments with a view of confirming that opinion. It however appears from thoſe facts, that pus, inſtead of being ſecreted from the veſſels, only obtains a globular and a purulent form after extravaſation; and, conſequently, that it is not produced as Mr. Hunter ſuppoſed, and

---

* I could mention other caſes of a ſimilar kind. The inference from them is obvious. Whilſt the general habit continues good, the ſerum retains its preſervative properties, and therefore continues fluid. When emaciation and diſeaſe take place, the ſerum loſes its preſervative properties; it coagulates, and ultimately aſſumes a purulent form.

and as Mr. Home has endeavoured to conclude *.

Mr. Home expoſed the ſurface of a healthy granulating ſore upon the upper ſurface of the prepuce of an healthy young man, about two inches ſquare, forming good pus: he wiped the ſore, and applied four very ſmall pieces of talc upon different parts of it, immediately afterwards covering the whole with a plaiſter of common cerate, ſpread upon lint, to take off the effect of expoſure.

In *five* minutes he removed one of the pieces of talc, and examined the fluid on its ſurface, which appeared like a thin tranſparent jelly divided into maſſes, but in which no globules could be diſtinguiſhed.

Exper. 4. In *ten* minutes another piece was examined, and the appearance was like the former; but at the bottom a number of ſmall globules could be readily diſcerned.

In *fifteen* minutes a third piece was examined, and the whole maſs appeared to be made of ſmall globules; but theſe were almoſt tranſparent, and ſeemed to become more diſtinct and opaque while looking at them.

---

* See Mr. Home's Diſſertation on the Properties of Pus, that gained him the prize medal given by the Lyceum Medicum Londinenſe.

In *twenty* minutes the fourth piece was examined, the globules were found more numerous and more opaque, like thoſe of common pus.

It is impoſſible for facts to be more deciſive than thoſe I have related, to prove that pus is not formed by the action of veſſels; but, on the contrary, that it proceeds from the natural ſtate of decompoſition which blood ſuſtains, when it loſes its preſervative properties, and changes from a fluid to a ſolid or coagulated ſtate, and finally to a purulent one.

That the coagulation of the ſerum does not proceed from the action of the granulations is proved, as deciſively as that it does not proceed from the action of the veſſels.

Exper. 5. The ſore being expoſed and wiped dry, Mr. H. applied to different parts of its ſurface two pieces of talc, and covered the whole as in Exper. 4. In five minutes he removed one piece, and found the tranſparent fluid mentioned above, but no globules. He then covered the ſurface of the talc on which the fluid lay with another piece of talc, to prevent the fluid coming in contact with the granulations, and applied it again to the ſore. In twenty-five minutes more he examined it by the microſcope, as alſo the fluid upon the other piece of talc which had remained thirty minutes upon the ſore, and found, in both of them, the globules diſtinct and very numerous; but moſt ſo upon the portion of talc in contact with the ſore. This proves, ſays Mr. H. "that after the fluid is once ſeparated from the veſſels, its becoming globular is a change taking place within itſelf, independent of the ſore which ſecretes it." He might have added, that this change is owing to the ſerous fluid having loſt the power of retaining its fluid ſtate, and that it therefore becomes globular—in the ſame manner as milk, when it becomes ſour, ſeparates and coagulates, in part forming cream; or as bile and urine, when they concrete, forming biliary and urinary calculi. I ſhall relate the next experiment; as the gradual change that took place in the fluid ſerum, to a ſolid or coagulated form, was particularly noticed.

Exper. 6. I applied, ſays Mr. H. a piece of talc as before, and covered the whole ſore for two minutes. It was removed, and its ſurface examined by the microſcope: at firſt no globules appeared: the examination was continued five minutes, in which time the globules became exceedingly diſtinct to my own eye, and to the eye of another perſon well verſed in microſcopical experiments.

There is every reaſon to ſuppoſe, that during the active ſtate of inflammation, the terminated extremities of the veſſels are diminiſhed, ſo that none but the moſt ſubtle parts of the blood can flow through; thoſe parts that preſerve their fluid ſtate, and therefore are not prone to coagulate: on the contrary, when the contracted ſtate of the veſſels becomes relaxed by the termination of inflammation, not only the moſt ſerous but the moſt coagulable parts of the lymph are poured out: it very ſoon coagulates after it is diſcharged from the veſſel in which it is contained, aſſumes a globular, and ultimately a purulent form. The effect we behold produced by a common bliſter is in proof of this, where ſerum is at firſt diſcharged; and

Mr. Home obſerves, what indeed is obſervable by every one, that in indolent ulcers, whether the indolence ariſe from the nature of the conſtitution, weakneſs of the parts, or the nature of the inflammation, the pus is made up of globules and flaky particles floating in a tranſparent fluid; and theſe globules and flakes are in different proportions, according to the degree of indolence. This is particularly obſervable in ſcrophulous abſceſſes, preceded by a ſmall degree of inflammation; and it might indeed be added, that in abſceſſes that frequently occur without any inflammation preceding; when the whole of the ſyſtem is weak and its action languid, the matter which thoſe abſceſſes contain is ſo perfectly coagulated, that it is of a flaky appearance, and of a cheeſy conſiſtency. Mr. Home, however, does not conſider this matter as pus. The name of a thing ſignifies not; the thing to be proved is this, that coagulation takes place in weak habits, and eſpecially in weak diſeaſes, more perfectly than in ſtrong habits in a ſtate of health, or during the active ſtate of inflammatory diſeaſes; and conſequently that the ſpontaneous coagulation which the blood ſuſtains is a change from an healthy to a diſeaſed ſtate, from a living to a dying condition *.

I ſhall merely ſtate farther, that he expoſed pus to the action of different chemical menſtrua alſo, and found that of courſe it was more perfectly decompoſed, and totally killed, if I may ſo call it, and that conſequently this pus from a ropy aſſumed a more coagulated form.

Pus poured upon the vitriolic acid, left ſtanding two hours, becomes ſemi-opaque, and of a dark purple colour. With the nitrous acid it effervesces, the mixture becomes green, afterwards pellucid, and then yellow. With the phlogiſticated muriatic acid, in two days the mixture becomes an homogeneous aſh-coloured *maſs*.

Cauſtic volatile alkali forms with pus a very viſcid fluid, that ſuſtains the ſame change from the cauſtic alkaline lixivium. The neutral ſalts in ſolution have no effect upon pus.

---

* Obvious, and ſupported by facts, as this doctrine abſolutely is, I cannot expect that it will be generally adopted; on the contrary, I have no doubt that I ſhall be attacked for having advanced it. I ſhall, however, reſerve the

After having pointed out the progreſſive changes which the ſerum and coagulable lymph undergo from the pure and fluid ſtate in which they exiſt in living veſſels, to the ſtate of coagulation and of purulency to which they are changed, either from the effect of diſeaſe or from the operation upon them of chemical agents, it may be proper for me to trace and ſtate the final and ultimate materials which this ſtinking and purulent ſubſtance gives out when it is completely decompoſed. I ſhould not even mention them in this place, were not theſe materials nearly the ſame as thoſe that are obtained by the analyſis of blood; and I do not think it altogether irrelevant, after having endeavoured to aſcertain the property of this fluid when ſubſiſting in a living ſtate, to ſhew by chemical analyſis the materials of which it is compoſed when in a ſtate of decompoſition or death. We might however as well endeavour to aſcertain the properties of chyle by a chemical analyſis of the ſtinking fæces, as expect to attain

the privilege of a reply. I have thought it candid on my ſide to take from Mr. Home himſelf the facts from whence my concluſions are partly drawn.

a knowledge of blood from the condition of its different parts by ſeparation and decompoſition.

The Chemical Analyſis of Pus.

Freſh pus, it ſeems, according to Dr. Brugman, contains neither an acid or an alkali; but being allowed to remain expoſed to a moderate degree of heat, it takes on other properties, acquires a pungent ſmell; it changes the ſyrup of violets red; corrodes copper, turning it green, ſhews ſigns of an acid quality from taking on the acetous fermentation.

Subſequent experiments made by Mr. Home on pus, however, ſeem to contradict the aſſertion, and ſhew that pus does not undergo the acetous fermentation. He expoſed ſome pus to a moderate heat, and every half hour tried its effects on the ſyrup of blue violets, but a red colour could not be produced (which is the proper teſt): on the contrary, the change it underwent was that to a green.

The chemical analyſis of pus is as follows *: Eight ounces and a half of thick yellowiſh white pus, quite freſh and without ſmell, diſtilled in a ſand heat never raiſed above 212 degrees, yielded on the firſt day a limpid phlegm, firſt without any ſmell, but afterwards the ſmell of recent warm pus could be evidently diſtinguiſhed; the whole quantity, ſeven ounces, two drachms, nine grains.

---

* Vide Mr. Home's Diſſertation, page 23.

This phlegm contained neither an acid or an alkali, producing no change on the blue colour of violets, and, expoſed to heat, evaporated wholly away like diſtilled water.

After the phlegm a vapour roſe by degrees with an empyreumatic ſmell. A freſh receiver being applied to the retort, a whitiſh phlegm with an ungrateful ſmell and taſte [I have no doubt but that it was curſed naſty] was collected, in quantity three drachms.

This phlegm turned the infuſion of blue violets green, and formed a white precipitate upon being added to corroſive ſublimate, evidently ſhewing that it contained an alkali: from the taſte it proved to be the volatile alkali. With this phlegm a quantity of air was extricated. The heat being increaſed, a little of the dry volatile ſalt attached itſelf to the neck of the receiver, which was ſoon diſſolved and removed

moved by the vapour. A phlegm with a ſtronger ſmell and a yellowiſh oil, which from its weight fell to the bottom, was collected in another receiver, weighing 55 grains: the oil was empyreumatic, fluid, and free from acidity: the phlegm was found to contain a conſiderable quantity of volatile alkali.

An oil now began to riſe, deeper coloured, exceedingly fœtid and empyreumatic, with a thinner yellow oil with which it did not mix: the vapour of the volatile ſalt formed cryſtals, which attached themſelves to the ſides of the receiver.

The heat being now raiſed till the bottom of the retort was red-hot, a maſs was obtained of the oil and dry ſalt, weighing two drachms, one ſcruple, and fifteen grains: of this maſs one-fourth part was volatile alkali. Theſe empyreumatic oils, as far as could be obſerved, reſembled exactly a ſimilar oil obtained from blood.

The retort being cooled and broken, the caput mortuum was black, light, and ſhining, weighed three drachms and five grains: this was put into a crucible, and expoſed to a violent reverberatory fire for eight hours: there remained eight grains of reddiſh brown aſhes, with an earthy taſte not at all ſaline: theſe aſhes ſhewed a polarity, on the application of the magnet.

The aſhes being digeſted in warm diſtilled water, the liquor ſtrained and evaporated, no ſalt could be obtained from them: upon adding to them vitriolic acid, a ſmall part was diſſolved like calcareous earth; the greateſt part was neither affected by the vitriolic nor nitrous acids. The above analyſis proves, ſays Mr. Home, "that pus is compoſed of the ſame materials with the blood and animal jelly, and ſo far they are ſimilar; the ſame ſubſtances being produced from both. A knowledge however of the chemical properties gives little information reſpecting thoſe properties which diſtinguiſh pus from the other parts of an animal, or from the different ſecretions."

That this purulent matter is not produced from a ſolution or deſtruction of the ſolids, but from a mere depoſition of the exhalant outlet of the veſſels, is evidently proved from the collection of pus we frequently behold in circumſcribed cavities; and when there is no abraſion of the inveſting membrane, no ſolution

tion of continuity in the organ which thoſe cavities contain: it is proved when matter is formed in the cavity of the thorax between the pleura; in the abdomen and in the ſcrotum: it is found in open canals; in the urethra, by the common effect of gonorrhea, when purulent matter ſhall continue to be poured out in abundant quantities, without the leaſt ulceration in any part of that canal; and finally, it ſometimes happens that the veſſels of different parts are ſo extremely relaxed, that they not only permit the white parts of the blood to flow through, but they cannot retain the red: it is the caſe in the loweſt degrees of ſcurvy; the red parts themſelves not only coagulate, but they induce the coagulation of the ſerum alſo: it is evident by the thick ropy cruor which is generally ſmeared over the ſurface of ſcorbutic ſores; by petechiæ and vibices under the ſkin; by the gums ſmeared and covered with coagulated blood: it is marked on the face by the red colour of the tears that trickle and coagulate on the cheeks; by the bloody colour of the urine and fæces, and I might almoſt add of the perſpiration itſelf. In the caſe of putrid confluent ſmall-pox, I have ſeen patients bleed red particles at every pore, ſo that the whole ſurface of the body was a complete gore of coagulated blood *.

Of the Vitality of the Blood.

Although I deny to the blood any power of action within itſelf, and reject the proofs that are advanced, that coagulation is a teſt of its living power, I wiſh it to be eſpecially underſtood, that I unite in the fulleſt extent with Mr. Hunter, in believing that it poſſeſſes within itſelf the principle of vitality in common with the ſolid parts. We have indeed a negative proof of the previous exiſtence of vitality in the blood, by the decompoſition and death which we frequently behold it ſuſtain.

---

* I remember a caſe that was under my care of very violent ſcurvy, and that aroſe from no apparent exciting cauſe: it was in a boy four years old: although he was afflicted with a ſcrophulous taint, in every other reſpect he was what might be called of a robuſt diſpoſition. He belonged to parents that indulged him with the moſt proper food, and paid the utmoſt attention to his general mode of living. A number of vibices made their appearance under the ſkin in different parts of his body; in ſome parts they were as broad as the palm of the hand; his gums were ſpongy, and cruor occaſionally found in the morning upon them; his urine was red, and a number of clots of red blood were frequently voided with the fæces. I ordered him to take bark and fermented liquors, to breathe a pure air, and make uſe of moderate exerciſe. In about a month the vibices went off, and he perfectly recovered.

That a contrary opinion ſhould have been entertained, is only a proof of the total ſtate of ignorance that has hitherto exiſted with reſpect to the nature of life, and of the power by which the various phenomena of the animated ſyſtem are carried on.

Is it not true, that blood in the aggregate poſſeſſes preſervative properties, which it derives from the living power it contains?

Is it not true, that when this living power is either weakened or deſtroyed, ſeparation and decompoſition take place, and the phenomena of putrefaction ultimately enſue?

Is it not true, that the blood which the embryo receives poſſeſſes the principle of vitality within itſelf, and that it is by virtue of that principle that it is fitted to be organized and arranged by the vital power which the embryo contains?

Is it not true, that the organization which has been formed out of this living blood by the power of the ſyſtem in which it is contained, poſſeſſes the properties of vitality alſo? And does it not appear abſolutely neceſſary, that the blood ſhould poſſeſs, in common with the ſolid parts, a principle or living property common to the whole, in order that harmony may ſubſiſt between the parts? And, finally, is it not very evident, that many of the fluids that are produced by the ſpecific power of the glands upon the blood poſſeſs, in a very eminent degree, the power of life?

Will the power of life be denied to the ſemen, to that highly vital fluid, which is one of the principal agents in the proceſs of fœcundation? Will it be denied to the gaſtric juice; to that fluid which deſtroys, by virtue of its living power, the chemical or dead qualities of common matter, and imparts to it the living property it poſſeſſes in the formation of chyle? Will it be denied to the interſtitial fluid, ſo eſſential to the reſtoration of the waſte which the whole of the ſyſtem ſuſtains? to the coagulated ſerum which forms the cement or connecting medium for the union of divided parts? Will it be denied that the blood, in conſequence of the waſte it ſuſtains, is perpetually verging from a living to a dying ſtate; and that it is with a view of averting the evil that would enſue to the ſyſtem at large, if the death of the blood were permitted, that there are particular organs which are eſpecially deſtined to ſupply it with freſh materials, and preſerve the whole in a living codition?

Let us for a moment ſuppoſe that the negative is the caſe, and that the blood, inſtead of being alive, is either dying, or is actually dead. We ſhould then behold the red globules acting by virtue of the chemical qualities they poſſeſs; we ſhould find the iron and the colouring matter imparting their own properties to the other parts; we ſhould find the cruor not only putrid itſelf, but producing putrefaction to the veſſels in which it is contained; we ſhould find the coagulable lymph plugging up the capillary outlets of the veſſels through which it is deſigned to paſs; we ſhould find the different ſaline ſubſtances which the ſerum involves, and which are in a latent ſtate whilſt it is alive, acting by virtue of their chemical qualities, as in the dead urine; we ſhould behold every individual of the human ſpecies, and indeed every individual of every ſpecies, diſeaſed, dying and dead with a ſcurvy of the moſt malignant kind; we ſhould ſee death in every fluid, and find putrefaction to be the only eſſential attribute of every ſyſtem.

The Vitality of the Blood denied by Mr. J. Bell.

Convinced, as I am, that theſe conſequences would inevitably enſue, if the blood did not poſſeſs, in common with every other part, a living power; and which Mr. Hunter has, in my humble opinion, very judiciouſly named the materia vitæ diffuſa; I felt conſiderable ſurpriſe when I read a very modern author, in a very modern publication, treat this living property of the blood with deriſion and ſcorn, calling the life of the blood *the moſt monſtrous of all abſurdities*. The grounds upon which this doctrine is conſidered as the moſt monſtrous of all abſurdities are theſe, viz. "It ſeems to be againſt all the laws of nature, ſays Mr. Bell, page 83, that any fluid ſhould be endowed with life. A fluid is a body whoſe particles often are not homogeneous, have no ſtable connection with each other, change their place by motion, change their nature by chemical attractions, and form new arrangements;

a body which can have no perfect character, no permanent nature, no living power connected with it. But the definition of a ſolid is the reverſe of this. A ſolid, among every kind of metals, earths, or foſſils, is recognized by its peculiar form and arrangement of parts; and in the animal body, the arrangement of particles gives the permanent unchanging character of each part; and in the muſcles for example, or in the nerves, where feeling or irritability chiefly reſides, the form and mechaniſm of the ſolid is in each moſt peculiar, and is always the ſame."

Thus then it appears, that the death or the non-vitality of the blood is aſſumed as a fact in the firſt inſtance, becauſe it is againſt all the laws of nature: it appears to me to betray the greateſt poſſible ignorance of phyſiological knowledge, to pretend to apply the laws by which the animated ſyſtem is governed to thoſe that regulate the properties of dead or common matter, becauſe we find that the one are totally oppoſite and different from thoſe of the other. As little reaſon is there for denying the vitality in any of our fluids on account of the want of connection, the mutability of their nature, and

the

the changes to which they are expoſed by the operation of chemical bodies.

The portion of the blood that is eſpecially employed for the reſtoration of parts, is homogeneous in its nature. Its properties are perhaps more permanent than thoſe of the ſolids *, and chemical bodies have as powerful an effect upon the ſolids as they have upon the blood. If we are to attach vitality to the parts from the immutability it is imagined they poſſeſs, there is not a particle of any one ſyſtem that retains vitality for any one moment; for the whole is in a conſtant ſtate of mutability and decay. Mr. Bell, aware I ſuppoſe of the fact, does not reſort to living but to dead ſolids: he appeals "to ſolids of every kind, to metals, earths, and foſſils, where the arrangement of parts is recogniſed." He indeed, it is true, "appeals at laſt to a part of the living ſolid, to the nerves, in proof that the life is in the ſolid, and this owing to its permanent and unchange-

---

* On trying the preſervative properties of the ſerum and of the muſcle of the ſame ſyſtem, I found that the muſcle decompoſed and putrefied much ſooner than the ſerum

able nature." To make this proof apply, he ought to have ſhewn that the ſolid part of the nerves is that portion in which ſenſibility reſides. If however it be true, that the nerves do contain a fluid, which is itſelf the ſource and cauſe of ſenſibility; the proof not only fails, but overturns the very hypotheſis which it is deſtined to ſupport. Mr. Bell indeed ſeems to talk of the ſerum of the blood, as he would of common pickle. He talks of "*making artificial ſerum*, *by impregnating water with ſalt*," page 91. Does he mean ſeriouſly to maintain that he could form ſerum by uniting with water the particular ſalts which are obtained by decompoſition from ſerum? The nature of both would be found totally different: the mixture which would be thus formed would remain permanently the ſame for an indefinite period of time, and would never have the tendency to undergo the proceſs of putrefaction.

Serum, on the contrary, is verging to a ſtate of decompoſition from the moment it is obtained from the living ſyſtem, and finally undergoes the putrefactive proceſs. If we examine the effect which this factitious ſerum has when introduced into the veſſels of a living animal, it deranges the actions of the ſyſtem, and often ſuſpends them altogether, as experiments have proved. On the contrary, when the blood of one living animal is transfuſed into the blood-veſſels of another, ſuch is the harmony that ſubſiſts between both, that a ſtate of reſuſcitation as it were is produced: and I have ſeen a dog that had been purpoſely bled to ſuch a degree, that he lay down deſtitute of all action, become immediately reſuſcitated by transfuſing into his blood-veſſels a proper quantity of blood from the veſſels of another dog. Will Mr. Bell pretend that the ſame effect would have enſued from his pickle, if he could have added to it, by chemical means, the other conſtituent parts of the blood? He might with as much facility amalgamate a living muſcle out of dead materials, or form an animated ſyſtem out of plaſter of Paris *.

---

* Holding it as I do an act of politeneſs to accommodate my language and my manner to the language and manner of the perſons I addreſs, I have in conſequence been obliged to depart from the mode to which I am uſed,

From all that has been ſaid we may be warranted to conclude, that the blood has a conſtant tendency to decay, in common with every other part of living matter, but more eſpecially from the waſte which it ſuſtains. The waſte it ſuſtains in the fœtal ſtate is far leſs than in the adult. In the former it is ſolely deſtined to ſupply nouriſhment and ſupport to the ſyſtem, with a view to the proceſs of evolution in general: in the latter, it is not only deſtined to be ſubſervient to the proceſs of evolution, and to preſerve it in a perfect ſtate after it has been evolved, but it ſuffers an additional and conſiderable waſte from the ſpecific action which the different organs diſplay; ſo that, inſtead of an equality in the diſtribution of the blood with a view to evolution alone, there is an inequality for the purpoſe of ſpecific action alſo. We may perhaps be led in ſome degree to conceive the progreſſive deterioration which the blood undergoes, by comparing the difference

for the purpoſe of accommodating and making it palatable to Mr. Bell. He will, I am perſuaded, take in good part the few ſtrictures I have made on his ill-directed ſarcaſm upon Mr. Hunter. It would take more room than I can ſpare to enter any further upon the ſubject.

of its colour in different periods of life and in different ſyſtems of veſſels.

In the early period of geſtation, the fœtus in utero appears to be altogether of a white colour; not only the external, but the internal parts; not only the ſolids, but the fluids alſo. As it proceeds in its evolution, inſtead of a ſameneſs a difference of colour becomes apparent, the whiteneſs gradually darkens, the different organs progreſſively obtain the colour which they are ultimately deſtined to aſſume, and the blood itſelf, from white, becomes alſo florid and red.

That the fœtal blood does not obtain the redneſs of its colour from the maternal ſyſtem, is evident from the nature of the fluid which the maternal placenta ſupplies, and which the umbilical veins abſorb. This fluid is of a ſerous colour, not of a red; on the contrary, the blood which is returned from the fœtus to the placenta is not of a ſerous but of a florid colour: it is therefore lawful to conclude, that it is in the courſe of its circuit in the fœtus itſelf that it loſes its white and obtains its red appearance; redder in the umbilical arteries than in the umbilical veins; redder in the trunk itſelf than its capillary extremities: and finally, if we examine and compare the colour of the adult blood, as it ſubſiſts in different ſyſtems of veſſels, we ſhall find that it is more florid and white as it proceeds from the lungs to the different parts of the body, than it is when it returns from the different parts of the body to the lungs, deepening gradually in colour until it becomes black and purpliſh. The means by which it is meliorated from theſe ſeveral degrees of deterioration which it undergoes, however different they may be, have evidently the ſame end in view. In the fœtal ſtate, the melioration is effected by the power of the placenta as its auxiliary organ; in the adult ſtate, the blood is repaired and renewed from the increaſed waſte it undergoes by the power of its own organs, the reſpiratory and chylopoetic together. It is therefore neceſſary that we ſhould inveſtigate the changes which the ſyſtem ſuſtains when the fœtal ſtate is ended and the adult begun, and the cauſes by which theſe changes are produced.

CHAP. IV.

ON INSPIRATION.

Before parturition, the different organs of ſenſe and of ſenſation are in a paſſive ſtate, owing to the harmony that ſubſiſts between them and the medium in which they are placed —after parturition, the irritation they ſuſtain from external cauſes excites them to act—the internal capacity of the cheſt is enlarged laterally by the action of the intercoſtal muſcle; longitudinally by the action of the diaphragm—the mouth is opened by the muſcles of the face—the air ruſhes into the mouth, and, through the medium of the trachea, diſtends the bronchia, conſtituting inſpiration—the quantity of air taken in, eſtimated—the qualities of it aſcertained—a part only of the whole poſſeſſes the aptitude to be acted upon by the lungs —is ſeparated from the reſt, and abſorbed—the power by which the effect is produced, aſcertained to be a living, not a chemical, act—ſimilar to the act of digeſtion by the ſtomach —the blood meliorated by the influence of vital air, &c. &c. &c.

ADMITTING the fact, that the blood is in a perpetual ſtate of deterioration and decay, it is neceſſary for me to point out the means by which it becomes meliorated and improved, ſo that it may continue fit to anſwer the purpoſes of nouriſhment and ſupport, for which it is eſpecially deſigned.

Such is the harmony that ſubſiſts between the fœtus and the liquor amnii, that the different organs of ſenſe and of ſenſation, of conſciouſneſs and of voluntary motion, are in a paſſive ſtate; the mouth is cloſed, the thorax is depreſſed on the collapſed lungs, and the abdominal muſcles exert no influence either on the abdominal or thoracic viſcera.

That the paſſive condition of theſe organs proceeds from the harmony that ſubſiſts between them and the medium in which they are placed, ſo long as they are excluded from the operation of external ſtimuli, is very conſonant to reaſon; but the opinion itſelf has received additional confirmation by ſome experiments that were made by Monſ. Buffon. He immerſed in water, of the ſame temperature as the liquor amnii, young puppies immediately after parturition, before they had ſuſtained the action of external cauſes, and he found that they continued to retain the different properties they poſſeſſed in the fœtal ſtate: "I procured, ſays he, a pregnant bitch of the large greyhound kind; and when juſt about to litter, I put her ſo in a bucket full of warm water that her hinder parts were entirely covered. In this ſituation ſhe brought forth three puppies; which, after being diſengaged from their membranes, were immerſed in a fluid nearly of an equal temperature with that of the amnion. After aſſiſting the mother and waſhing the puppies in this water, I ſuddenly removed them into a pail of warm milk, without allowing them time to reſpire. I kept them immerſed in the milk for more than half an hour, and when taken out all three were alive—they then began to breathe, and they diſcharged a quantity of fluid matter from the mouth."

Such is the increaſed waſte which the blood ſuſtains in conſequence of thoſe actions which the animated ſyſtem performs in the adult condition, that the auxiliary organ (the placenta) it poſſeſſed in the fœtal ſtate is inſufficient to anſwer the purpoſe of melioration. Providence, therefore, has ſupplied the adult with organs that are equal to the taſk: whilſt the lungs improve the blood in point of quality, the chylopoetic organs ſupply the loſs it ſuſtains in point of quantity—ſo that, by the combined and co-operating action of both, the animated ſyſtem is ſupplied with the means by which the final cauſe of its exiſtence may be attained.

The actions which the auxiliary organs performed in the fœtal ſtate progreſſively diminiſh, and ultimately ceaſe, in proportion as the actions of the organs in the adult are excited, and perfectly eſtabliſhed.

The connection between the fœtus and the mother does not immediately ceaſe after it is expelled from the uterus. If the ſeparation have not been cut off by a diviſion of the funis, the umbilical arteries are found to pulſate in a very powerful degree. Such is the active condition of theſe veſſels, and the quantity of blood they return from the ſyſtem to the placenta, that, if they were divided at that time, a copious hæmorrhage would immediately enſue—to ſuch a degree indeed, that, if it were allowed to continue, the death of the infant would be the immediate conſequence *.

But

---

* Although I have occaſionally known the pulſation of theſe veſſels to be ſynchronous with that of the mother, it is very ſeldom the caſe; ſo that we may conclude, that the

But as ſoon as the fœtal ſtate is ended, and the adult begun, the animated ſyſtem becomes placed in a new condition; the harmony and conſent that ſubſiſted between the fœtus and the medium by which it was ſurrounded immediately terminate; irritation and diſcord between both conſequently commence. In the fœtal ſtate, it was prediſpoſition to act, with a capacity alone of acting; in the adult ſtate, it is prediſpoſition ended, and action in full force. The different parts of the ſyſtem are therefore rouſed from the paſſive ſtate in which they exiſted, and act according to the ſpecific power they ſeverally poſſeſs; the impreſſions from without, which the organs of ſenſe and nerves of ſenſation receive, are propagated to the brain within, as the organ of conſciouſneſs: it is by the energy of this organ that the different voluntary muſcles of the infant frame are made to act, without apparent deſign or any determinate object.

the motion of the blood in the fœtus is effected by a power diſtinct from what it is in the maternal ſyſtem.

Of the Manner in which the Internal Capacity of the Thorax is enlarged.

It is in conſequence of the nervous irritation produced, that muſcular action takes place, and the capacity of the thorax is conſequently enlarged *.

The firſt rib, which is immoveably fixed, may be conſidered as a lever to the reſt: the articulation which the true ribs poſſeſs, with the vertebræ behind and ſternum before, gives them a gradually increaſed capacity of being moved. This capacity in the five inferior ribs increaſes in a ten-fold degree, in conſequence of the anterior extremities having no fixed attachment like any of the reſt.

The intercoſtal muſcles conſtitute the inſtruments by the power of which the ribs are elevated: their attachment begins from the inferior edge of the ſuperior rib, and terminates in the ſuperior edge of the inferior one; ſo that the elevation of the inferior rib muſt eventually be the effect of their action. The ſame mode of action is propagated throughout the reſt; the form of theſe muſcles and the mode of their attachment muſt evidently be to elevate the ribs, and to increaſe the internal capacity of the cheſt in a lateral direction, ſo that a conſiderable vacant ſpace is conſequently left between them and the collapſed lungs.

---

* It is unneceſſary for me to enter into a particular anatomical account of the ſtructure of different parts: it would ſwell out this book to a great ſize with matter, which ought to be known by every medical man from diſſection, and may be obtained by every one indiſcriminately from different anatomical authors. I know none ſo correct as Winſlow.

Had the firſt rib been moveable inſtead of fixed, and had the lower rib been fixed inſtead of being moveable, the effect would have been exactly the reverſe; the action of the intercoſtal muſcles would have been from below upwards, inſtead of being, what it is, from upwards below.

Whilſt the enlargement of the thorax takes place by the action of the intercoſtal muſcles from ſide to ſide, the longitudinal dimenſion of it is conſiderably increaſed alſo. In the fœtal ſtate, the diaphragm formed a conſiderable curve upwards, adapting itſelf to the collapſed ſtate of the lungs; but when the thorax is laterally enlarged by the elevation of the ribs, the diaphragm is drawn down, from a curve, in which it exiſted in the fœtal ſtate, to a plane; and thus it is that the internal capacity of the thorax is conſiderably enlarged by the united alteration which the ribs and diaphragm ſeverally undergo.

The muſcles of the face are excited to act in common with thoſe of the thorax; ſo that the mouth, which in the fœtal ſtate was perfectly cloſed, becomes immediately opened: the column of air, by which the infant is ſurrounded, obtains a free admiſſion into the mouth, which may be conſidered as a cavity common to the reſpiratory and alimentary canals: the air paſſes from the mouth, through the medium of the epiglottis, into the larynx. The *larynx* is compoſed of five cartilages, at the termination of which the trachea more immediately begins, of which it is a continuation: the *trachea* extends, in one undivided canal, as far as the fourth vertebra of the back, and there divides into two branches: each branch becomes diſtributed into an infinite number of ſmall ramifications, which poſſeſs, although in an inferior degree, the ſame cartilaginous character as the larger trunk: the cartilaginous nature of the trachea ſeems evidently deſigned to preſerve it in a patent ſtate; it is covered over with a membrane, in which a multitude of glands are placed, which ſecrete a mucus on its ſurface: the ramifications of the bronchia ultimately terminate in the cellular ſubſtance of the lungs.

It does not appear that the air, in its paſſage through the trachea, undergoes any chemical change in its qualities other than modification in its temperature, by the influence of the medium through which it is to paſs: the length of the trachea is particularly fitted for that office: if the air be too cold it is warmed; if it be too warm it is cooled; ſo that it is brought to a medium ſtate, and fitted for the action of the lungs which it is deſtined to ſupply.

The lungs are two in number, each divided into two large lobes, and each lobe into ſmaller lobules; they are externally covered over by a thin membrane, which perpetually exhales from its ſurface a fine halitus or vapour, conſtituting the medium by which they are prevented from adhering to the parietes of the cavity in which they are contained. As ſoon as the mouth is opened the air ruſhes into it, and paſſes through the medium of the epiglottis into the bronchia, which it completely fills; the diſtenſion which the bronchia ſuſtains, not only fills up the hollow ſpaces that were laterally formed in conſequence of the elevation of the ribs, but it preſſes down the diaphragm alſo. The diaphragm is a ſtrong muſcle which ſeparates the cavity of the thorax from that of the abdomen; in the fœtal ſtate it is convex towards the lungs, and concave towards the abdominal viſcera: it is attached to the edge of the inferior ribs, ſo that when they become elevated by the action of the intercoſtal muſcles, the poſition of the diaphragm, as I have before obſerved, becomes altered from a curve, in which it exiſted in the fœtal ſtate, to a plane; and thus it is that the internal capacity of the thorax is conſiderably enlarged by the united alterations which the ribs and diaphragm ſeverally undergo. So that inſpiration may be ſaid to have happened when theſe different phenomena have taken place.

Various attempts have been made by different men at different times, as Borelli, Jurin, Goodwin, &c. to calculate the quantity of air which the lungs have received in conſequence of the diſtenſion they have ſuſtained. It is however very evident, that it muſt vary in the ſame ſyſtem at different periods of life, as well as at different periods in perſons of the ſame age.

So long ago as the middle of the laſt century, Borelli breathed through a glaſs tube, one end of which was immerſed in ſome bubbles of ſoap; and the internal volume of air it contained having been previouſly aſcertained, he found the quantity of air exhauſted from the glaſs tube, and which he ſuppoſed to have been received into the lungs at one inſpiration, to amount to 15 cubic inches and upwards.

Dr. Jurin, wiſhing to aſcertain the fact, formed the following experiment, which he thus relates: "I ſuſpended (ſays he) a weight "to the lower part of a bladder which I had "previouſly moiſtened; and having fixed a "tube of about an inch diameter in the "upper part, I ſtopped my noſtrils, and in"ſpired the air of the bladder gently during "three minutes, the weight remaining all the "while on the table. I then plunged the "bladder with the air encloſed in it, and the "weight ſuſpended to it, into water contained "in a cylindrical veſſel. I marked the height "to which the water roſe. Then having "ſqueezed the air out of the bladder, I again

" plunged it into the water with the weight.
" The difference of the height to which the
" water roſe in both theſe caſes was eaſily cal-
" culated. Having repeated the experiment
" ten times, and added the quantities together,
" the tenth part of the ſum total, or the pro-
" portional difference of the height to which
" the water roſe in both caſes, was found equal
" to 35 cubic ounces, which is the volume of
" air contained in the bladder; and having
" added about a 12th part, or three ounces,
" on account of the condenſation of the air
" from the coldneſs of the water, as it was
" winter, we ſhall have 38 cubic ounces. Be-
" ſides, a little muſt be added, both on account
" of the preſſure of the water on the bladder,
" and of the moiſture which is expelled with
" the air, and ſoon condenſed by the coolneſs
" of the water and of the bladder. I then
" calculated the quantity of air expelled by a
" moderate expiration in the ſpace of three
" minutes at 40 cubic ounces. In the ſtrong-
" eſt expiration I expelled 125 cubic ounces
" in the ſpace of a minute; but in a very
" ſtrong expiration, continued till I was al-
" moſt ſuffocated, I expelled 220 cubic ounces
" from my lungs: from whence it follows,

" that

"that there is more air in the lungs than can "be expelled by an ordinary expiration."

Dr. Goodwin has inveſtigated the ſame ſubject with great diligence and attention. The experiments he performed, although they do not exactly correſpond with each other or with thoſe above detailed, are of conſiderable importance, and merit to be mentioned in this place. The mode he adopted was as follows: He breathed from a veſſel which had two tubular openings; one of them was applied to the mouth, whilſt the other was immerſed in water. By inſpiring from the veſſel under theſe circumſtances, a quantity of water entered the veſſel equal in volume to the quantity of air inſpired from it *.

Exper. 2. An adult perſon of ordinary ſtature inſpired twice from the machine, imitating as nearly as poſſible an ordinary inſpiration.

In the firſt he took in 3 cubic inches of air.

In the ſecond, 2½ cubic inches.

Another perſon of nearly the ſame ſtature inſpired twice:

In the firſt he took in 3⅕ cubic inches of air.

In the ſecond, 2¼ cubic inches of air.

---

* See his Diſſertation on Suſpended Animation; the production of a man of ſcience and of genius, in which a plate is inſerted deſcribing the pneumatic machine he employed.

Exper. 3. The two perſons employed in the laſt experiment inſpired from the pneumatic veſſel thirty times ſucceſſively in the manner juſt deſcribed, and the average quantity of air taken in at a ſingle inſpiration by the firſt perſon was 2¾ cubic inches.

By the ſecond, 3⅙.

Theſe experiments were repeated on a great variety of ſubjects with the ſame reſult.

Objections however have been made to the manner in which theſe experiments were conducted. It has been ſuppoſed, that the column of water, by being raiſed, contrary to its natural gravity, would conſequently meet with additional reſiſtance; that the difference of temperature to which the air would be expoſed by paſſing from one veſſel to another, would produce a difference in the volume it occupied.

With a view of avoiding theſe objections, Dr. Menzies took an allantois, to which he fixed a tube with good valves joined to it. He was led to take this membrane on account of its thinneſs, which could not condenſe the air in a great degree; and from its magnitude, the average quantity of the number of expirations could be eaſily taken. *Exper.* Having firſt meaſured the volume of an allantoid in two different ways, firſt by the quantity of water it was capable of containing, and afterwards by the diameter and area of it, I found it, ſays he, to be nearly equal to 2400 cubic inches; and having joined it to a machine conſiſting of two pretty large tubes joined at right angles, in which there are two valves, ſo that the air without any unuſual effort could be inſpired through the one and expired through the other; the valves which are made out of the allantoid are ſo thin that the ſmalleſt force moves them. I then began to expire, and did not remove my mouth from the tube till I had filled the allantoid, taking care to ſtop my noſtrils during expiration. The allantoid was filled, on repeated trials, by about 56 expirations as natural as poſſible; ſo that if you divide 2400 cubic inches, the volume of the allantoid, by 56, you will have 42.8 cubic inches as the average quantity of air uſually expired. Several perſons of a middle ſize repeated this experiment with nearly the ſame reſult: the experiment was varied in different ways, and the reſult was generally the ſame. I have repeated ſome experiments with a view of aſcertaining this point, at the time that the temperature of the air was at 60°. I found that I inſpired, during a full inſpiration, twelve cubic inches; and making allowance for the expanſion it underwent in conſequence of the increaſed temperature in the medium through which it was to paſs, it may perhaps be correct when we ſtate, that the lungs receive, during a full inſpiration, about twenty cubic inches of atmoſpheric air.

As ſoon as a column of air is introduced by the act of inſpiration into the bronchia of a living animal, a part only of the whole poſſeſſes the aptitude to be acted upon by the lungs, and to receive from them the participation of life which they convey: it is this portion, which the lungs have ſeparated from the whole, that may be truly called *vital air*; it is then vital air, becauſe it conſtitutes a part of the ſyſtem, and is in harmony with the whole.

Of the Conſtituent Parts of Atmoſpheric Air.

A few years only have elapſed ſince the diſcovery has been made, that the atmoſpheric medium in which we exiſt is compoſed of different kinds of air, poſſeſſing in their nature various and oppoſite properties, and which poſſeſs very different degrees of aptitude to be acted upon by the lungs of the human ſpecies. To Dr. Prieſtley the merit of this diſcovery unqueſtionably belongs, and for which he is entitled to every degree of obligation. Although the conſtituent parts will neceſſarily vary in different ſituations, whether town or country, and even in different ſituations of both, it is however found in general, that if 100 parts of common atmoſpheric air be analyſed, it yields

Eighty parts of phlogiſticated air,
Eighteen parts of oxygenous air,
And two parts of fixed air.

When a volume of this air above deſcribed has been inſpired into the lungs, and a ſimilar quantity of it expelled, the quantity expelled by chemical analyſis is found to have acquired properties very different from thoſe it originally poſſeſſed.

The quantity of fixed air is increaſed to the proportion of 15.

The phlogiſticated air at 80 continues much the ſame.

But the oxygene air is reduced in the proportion of 18 to 5. Theſe proportions muſt neceſſarily vary in different ſubjects, and perhaps in the ſame ſubject at different times. It is however doubted by many very reſpectable men, whether oxygene be ever abſorbed: on the contrary it is ſuſpected that caloric alone, the baſe of oxygene, is received, and that the oxygenous principle, which is in conſequence decompoſed, unites with carbon, which is given out from the exhalant termination of the pulmonary arteries; and thus it is that fixed air is formed. Although it is very true that the addition of fixed air may be accounted for in this mode, there does not appear any reaſonable ground to doubt, that the air itſelf is ſuſceptible of being taken in by the lungs. There have been various experiments made by a ſociety of gentlemen that uſed to meet at Dr. Higgins's, in Greek-ſtreet, and it was found, that although the oxygenous air received by inſpiration ſuſtained a conſiderable degree of diminution, yet that the other conſtituent parts in the column of atmoſpheric air were frequently found deficient alſo; and it was ultimately concluded, that although oxygene was the uſual portion received, it was not invariably the caſe *.

---

* It is not becauſe oxygene poſſeſſes the greateſt aptitude to be acted upon by the lungs of the human ſpecies, in the ſame manner as the trail or fæces of a woodcock or a ſnipe to be digeſted by the power of the ſtomach, that the one is to be conſidered the cauſe of vitality to the ſyſtem by which it is received. Theſe ſubſtances conſtitute the food

Of the Power by which the Separation of particular Parts of the Air is effected.

Admitting then that there is a quantity of air, which is introduced into the bronchia during every act of inſpiration, it becomes a queſtion of importance to determine by what power it is that the ſeparation of ſome of its parts is effected. The modes by which this effect can be produced are referable to two;—either that it proceeds from a chemical union taking place between the air and the organs, or that it is effected by the power of the organs alone, acting upon thoſe parts of the air which poſſeſs the aptitude to receive their influence.

If it be ſuppoſed for a moment that it proceeds from a chemical union taking place, it is ſuppoſing the ſame operations are performed on the living ſyſtem as we behold produced amongſt dead matter.

It appears to me very unreaſonable to imagine, that the ſeparation that takes place

---

food only, the ſubject matter on which the living organs act. If the organs were dead, all the oxygene in the univerſe would be inſufficient to produce vitality in the human frame. Oxygene is as inanimate until it has been aſſimilated by the power of the lungs, as the azote or carbonic acid gas, until it has been acted upon and digeſted by the aſſimilating organs of the vegetable ſyſtem.

is the conſequence of a chemical union between the air and the different parts of the animated ſyſtem; becauſe ſuch an union, inſtead of increaſing, has a conſtant tendency to deſtroy the organization of the part. Theſe are the effects that conſtantly enſue by the chemical operation of the air upon animal matter, when once the operations of life have ceaſed: inſtead of a ſeparation taking place of particular parts, there is a combination of the whole, not of the air only, but of the air and of the animal matter with which it is connected: inſtead of animal vitality being preſerved and continued, putrefaction is accelerated, and the whole becomes finally decompoſed into its conſtituent parts. Why then ſhould we ſuppoſe that the mode which is found to accelerate the diſſolution of animal matter ſhould be employed for the preſervation and continuation of life? On the contrary, it appears to me more reaſonable to conclude, that the ſeparation of different parts of the air, which takes place, proceeds from the power of the lungs alone, acting upon and ſeparating thoſe parts of the air which poſſeſs the aptitude to be acted upon by them; that it is a living and not a chemical act, ſimilar to the act of digeſtion by the ſtomach. It is thus that I aſcribe to the lungs the importance they deſerve, and refer to them the true office which they are deſtined to perform.

That the action of the lungs upon the air, by means of which it becomes aſſimilated to the nature of the animated ſyſtem, and that it is the union of this vital air with the blood which conſtitutes the means by which it becomes fitted to be conveyed by the vaſcular ſyſtem to the different parts of the ſyſtem, is proved by the negative of the caſe, either when air is altogether excluded, or when air is introduced that does not poſſeſs the aptitude to be acted upon by the lungs. The blood is then deprived of the melioration it demands; inſtead of being moved, it ſtagnates; inſtead of becoming florid, it continues black; inſtead of remaining fluid, it generally coagulates, and aſſumes a ſolid form.

Experiment by Mr. Coleman. A dog was ſuſpended by the neck, and in three minutes he ceaſed to move; the trachea was then laid bare and divided, and the lungs fully diſtended with warm water (blood heat) through the medium of a funnel, the trachea being ſecured ſo as to permit no water to eſcape. The cheſt was opened: a larger quantity of blood was found in the left ſide of the heart than in the right auricle, ventricle, or pulmonary arteries; the left was loaded with blood partly coagulated, and the whole quite black. The experiment was repeated, and yielded nearly the ſame reſult.

Exper. 1. A ſmall rabbit was deſtroyed in nitrous air: as ſoon as it diſcontinued to expire air from the lungs, it was removed from the medium in which it had been plunged; a ſmall aperture was then made in the trachea, and the lungs diſtended with common air: the trachea was tied, and the air retained: on examining the heart, the proportion of blood on the left was to that of the right as 7 to 6.

2. The ſame experiment was tried and repeated by deſtroying another animal in fixed air, and then diſtending the lungs with nitrous air: the proportion of blood in the left ſide of the heart was to that of the right as 13 to 12. In ſome caſes, however, it appeared that the proportion of blood on both ſides was either equal, or even rather a larger proportion in the right than in the left.

3. A dog was drowned: when he ceaſed to move, cold water was introduced into the lungs: on examining the heart, we found the

proportion of blood in the left was to that of the right as 6 to 5.

Exper. The trachea of a kitten was laid bare, and a ligature paſſed round it, that the whole of the air might be confined within the lungs: the animal ceaſed to move in four minutes and a half: on opening the heart, the proportion of blood on the left ſide was to that of the right as 9 to 7.

The proportion in a cat deſtroyed by the ſame means, was as 5 to 4.

I might add my own teſtimony, by relating the number of men who fall victims to the choke damp in coal mines, or who imprudently inhale the vapour that exhales from different vegetable ſubſtances during the act of fermentation, particularly in breweries and diſtilleries. It is the melancholy lot to which a particular ſet of men are eſpecially doomed (night-men). Two years ago I was called up to ſee five men, all of them under the age of thirty, and who were before in the fullneſs of health. The pipe leading from a water-cloſet having been choked, they were directed to remove the obſtruction: three of them were in the reſervoir into which the pipe led: an old ſhoe which had been accidentally thrown down, had, it ſeems, ſtuck at the lower extremity of the pipe: as ſoon as it was removed, the whole contents of the pipe, which was full, guſhed down, and immerſed the men in the ſoil as high up as their knees: the vapour that immediately exhaled, ſuffocated two out of the three in an inſtant. One of the two who were out of the reſervoir, in endeavouring to extricate his companions, ſhared the ſame fate; and it was a conſiderable time before the ſurvivor recovered from the danger to which he was expoſed.

We may therefore conclude, that the action of the lungs upon the air conſtitutes the power by which the ſeparation is effected. Such is the ignorant ſtate of our knowledge at this time, that we cannot tell what other changes it may ſuſtain. I am, however, fully convinced, that the lungs require particular and different kinds of air at different times, as much as the ſtomach requires particular and different kinds of food at different periods of life. Such is the direct communication which the vital air has upon the blood, that the extent of its influence muſt be very conſiderable; and this is abundantly proved by the alteration of colour and conſiſtency it aſſumes.

It is now four years ſince I was ſatisfied that the lungs performed the office of aſſimilating or digeſtive organs, and that the only difference that ſubſiſted between them and the ſtomach, aroſe from the difference of the ſubſtances which each of them ſeparately digeſted; whilſt the lungs acted upon and aſſimilated air with a view of meliorating the blood in point of quality, the ſtomach acted upon groſſer materials, in order that the blood might be conſtantly ſupplied in point of quantity; but that both theſe organs performed one and the ſame office, by acting upon things foreign to the ſyſtem, and aſſimilating them to its own nature.

It was from this mode of reaſoning that I was led to ſuſpect, that the application of different ſpecies of air to the lungs, under different circumſtances, might prove highly beneficial. I had in common with every one witneſſed the good conſequences that all experience by the inſpiration of an atmoſphere congenial to the ſyſtem. I had known ſeveral perſons, and had heard and read of a multitude of others that had been inſtantly deſtroyed by inhaling noxious vapours. I had ſeen perſons labouring with aſthmas, almoſt ſuffocated by a change of weather, and again ſuddenly relieved by the ſame means. With facts ſuch as theſe, a man muſt have been imbecile indeed not to have an idea of applying particular kinds of air by inſpiration to the cure of different complaints. Holding however, as I do, in the utmoſt abhorrence, experiments on living animals, I never applied my ideas to practice. The medical treatment of diſeaſes by this means has been taken up by Dr. Beddoes, and proſecuted with conſiderable zeal, and I believe ſucceſs, by Dr. Thornton. I certainly do know a caſe where it is attended with very evident and extraordinary good effects; and I have reaſon to believe, that the life of the patient has been prolonged by the inhalation of different ſpecies of air from the pneumatic machine*.

The

---

* I have no other motive in view than a ſincere wiſh of averting the calamities to which the human frame is conſtantly expoſed, and hope that remedies may be found by means of which they may be relieved and cured. I have not myſelf applied the pneumatic ſyſtem to the cure

of

The Blood meliorated by the Union of Vital Air.

That the air which the lungs have aſſimilated exerts its influence on the blood, and makes it change from a purple to a florid colour, is a fact that was aſcertained by Lower one hundred years ago. It has been further confirmed in more modern days by a multitude of experiments made on living animals. It is a great conſolation to the phyſiologiſts of the preſent day, that the number of experiments that have been made for the purpoſe of aſcertaining this point, render any further ſacrifices totally unneceſſary. I ſhall merely mention the names of Dr. Goodwin, of Mr. Hunter, and Mr. Coleman: theſe gentlemen have drowned and poiſoned as many cats and dogs as would completely choke up Houndſditch.

---

of diſeaſe: I wait for more facts and more experiments. When I ſee the plan properly eſtabliſhed (if it ever be ſo), I ſhall think it criminal in any practitioner, whether through obſtinacy or other motive, not to give into it. I am afraid, however, that it is too indiſcriminately employed at preſent, and that it will ſink into oblivion from an exceſs of zeal, and from the application of it being made too univerſal.

Dr. Goodwin procured ſeveral large dogs, removed the ſternum of each, and expoſed to view the trunks of the pulmonary arteries and veins, ſo as to allow him to diſtinguiſh accurately the colour of the blood that paſſed through them. The blood in the pulmonary artery was found to be black; the blood in the pulmonary veins was found to be florid and red. In theſe experiments it was obſerved, that although the blood in the trunk of the pulmonary artery was black during the inflation, the blood in the trunk of the pulmonary vein became florid and red; and when the inflation was interrupted for one minute, the blood in the trunk of the pulmonary vein became gradually black, like the blood in the trunk of the pulmonary artery, alternately changing from a deep red to a florid complexion during the act of inſpiration, and again loſing the florid complexion by ſuſpending the inflation until it regained its dark hue.

Let us hear Mr. Hunter's obſervations upon this ſubject. " If the air is confined in the lungs of a quadruped, it ſoon loſes its power over the blood, which remains dark. This experiment," ſays he, "I have repeated ſeveral times upon ſeveral animals, and commonly for half an hour at a time; which was ſufficient to allow me to make my obſervations with coolneſs and accuracy. In the firſt part of the experiment it was curious to ſee the coronary arteries turn darker and darker, becoming like the veins which run on each ſide of them; and, on blowing again, reſuming gradually a bright colour, till they became of a florid red. And again," ſays he, "when I continued the artificial bleeding, I obſerved that the blood in the pulmonary veins coming from the lungs, the left auricle and ventricle of the heart, aorta, &c. was florid in the proportion as I threw in air into the lungs, and dark again as I ſuſpended the inflation. I cut off a piece from the lungs, and found that the colour of the blood which came from the wound correſponded with the above effect. When I threw in air into the lungs, ſo as to render the blood florid in the pulmonary veins, two kinds of blood iſſued from the wound; and when I left off blowing, the whole blood which paſſed out was not florid and dark, but dark only."

Finally, Mr. Coleman "hanged up ſeveral unfortunate dogs; the ſternum was removed, and the lungs inflated until the blood in the pulmonary vein and left auricle of the heart became florid."

We may therefore admit it as a fact, that the air which the lungs have ſeparated, and which the blood in its paſſage through the lungs has received, is the cauſe of the florid colour it aſſumes. That black blood will be made red out of the body by the addition of oxygene, is a fact proved beyond all doubt. I took half an ounce of craſſamentum, which I kept four days, and which by that time was become perfectly black; I ſprinkled over it two drachms of pulverized nitre, which contains a large quantity of oxygene: in two hours the whole ſurface of the black craſſamentum was become red; and in two days the whole maſs was not only become red, but was changed from a ſolid to a fluid form.

Dr. Goodwin encloſed a quantity of oxygene air in a glaſs receiver inverted in quickſilver, and introduced into it four ounces of blood freſh drawn from the jugular vein of a ſheep: the blood became inſtantly very florid, and the quickſilver ſeemed to aſcend a little in the receiver.

When the lungs have not the power to act upon and ſeparate the air, or when air is introduced which does not poſſeſs the aptitude to be acted upon by them, the air in the bronchia preſerves its original properties, and the blood in the pulmonary veſſels continues unaltered; ſo that it does not obtain the melioration which it requires.

On the contrary, when the blood has received from the air the melioration it demands, ſuch is the aptitude it poſſeſſes to be moved, that the weakneſs of a vein is ſufficiently ſtrong to convey it from the lungs to the left ſide of the heart.

Dr. Goodwin inflated the lungs of ſeveral dogs, removed the ſternum, and expoſed the pericardium in ſuch a manner that the motion of the auricles and ventricles might be eaſily diſtinguiſhed. " I made (ſays he) theſe experiments with all the circumſpection here mentioned, and in the proceſs of inflation I carefully attended to the change in the colour of the blood, and in the correſponding contractions in the left auricle and ventricle of the heart; and in all the examples, I obſerved that when the blood which paſſed into the left auricle was florid, the auricle and ventricle contracted ſtrongly, and the circulation went on as in health; but when the blood began to put on a ſhade of brown, the contractions were diminiſhed; and when it was black the contractions ceaſed, and the functions of the body were ſuſpended: but as ſoon as the florid colour of the blood began to be reſtored, the auricles and ventricles reſumed their contractions; they gradually recovered their natural ſtate, and all the functions of the body returned."

Mr. Hunter ſays, that in the experiments he made, reſpiration was prevented in the beginning in conſequence of the time neceſſary to tie and adapt his apparatus; the blood therefore was of a dark colour, the heart large, and *hardly acting*; but on throwing into the lungs freſh air, the heart began to act, upon which both auricles and ventricles became gradually ſmaller: then by ſtopping the reſpiration they again became larger and larger.

If more were neceſſary to eſtabliſh the fact, that it is owing to the power of the lungs that the blood becomes fitted to be acted upon by the vaſcular ſyſtem, and that theſe organs may conſequently be called the punctum ſaliens from whence the blood begins to move; I ſhould bring forward the multitude of caſes which every obſtetric practitioner muſt have witneſſed, of children that have been apparently ſtill-born, but where the left ſide of the heart has been excited by means of artificial reſpiration (inflating the lungs). I ſhould relate by the ſame means the reſuſcitation of thoſe aparently killed by immerſion, of thoſe ſuffocated by the inhalation of noxious vapours, &c. &c.

In what Manner the Vital Air is conveyed into the Blood.

Such is the imperfection of our anatomical knowledge, that the fact is not yet aſcertained, whether the pulmonary veins have or have not an open orifice, by means of which the air is abſorbed and conveyed into the blood; or whether the air permeates their coats as the rays of light do the cornea of the eye.

Dr. Prieſtley introduced a portion of blood within a bladder, and by agitating a quantity of atmoſpheric air againſt the ſides, he found that the colour of the blood was changed in conſequence. It muſt however be remarked, that an experiment of this kind proves nothing with reſpect to the living actions of living parts; becauſe we find, that after thoſe actions have ceaſed, and none but thoſe of preſervation remain, a ſeparation takes place of the fibres, of which the coats of the bladder are compoſed; it becomes porous in conſequence, and would therefore readily admit the introduction of air. We find this to be eſpecially the caſe with the gall-bladder: as ſoon as the actions of life have ceaſed, the bile tranſudes its ſides, and tinges the ſurrounding parts.

Dr. Goodwin, aware I ſuppoſe of this circumſtance, diſſected the cellular membrane from the ſmall vein in the neck of ſeveral rabbits, and confined the blood within by means of ligatures; he then conducted a ſmall ſtream of dephlogiſticated air to the coats of the veſſels: in ſome of them, the blood became a little florid, but in others there was no diſtinct change, although the ſtream of air was conducted for two minutes." It would therefore

fore appear more probable, that the pulmonary veins have an abſorbent orifice, by means of which, the air is received which the lungs have aſſimilated, and that it then unites with the blood they contain, where it produces the effects we have deſcribed *.

It is owing to the high degree of vitality which the blood has in conſequence received, that its aptitude to be moved is proportionably increaſed. We are in the habit of ſaying, that it ſtimulates the vaſcular ſyſtem in a more powerful degree than it would otherwiſe do: it does not however appear to me, that this language is perfectly correct; the whole of the vaſcular ſyſtem is conſtantly prediſpoſed to act, provided it has a proper ſubject on which to operate: the blood itſelf is perfectly paſſive, and it is when deſtitute of ſtimulating properties that it contains in a

---

* That the air is taken up by the pulmonary veins, and not by the abſorbent lymphatic veſſels, is evident from this, that it produces its effect on the blood going to the *left* ſide of the heart; whereas, if it were taken up by the abſorbent veſſels, it would be conveyed through the medium of the ſubclavian vein into the *right* ſide, where it would produce its effect; and which it does not.

moſt eminent degree the capacity to be moved. If the properties of the blood be examined in different ſyſtems of veſſels in the pulmonary veins and pulmonary arteries, in its moſt pure and vital ſtate, or when it ſubſiſts in its moſt impure and dead one, we ſhall find, that in the one it is perfectly homogeneous, in appearance bland, and mild in its qualities; the air which it has received is in ſuch complete union with the whole, that it can ſcarcely be detected. Ligatures have been applied on a portion of the pulmonary vein, and the blood it contained encloſed within: it has been put under the receiver of an air pump, and the air exhauſted; but the vein did not ſwell or diſtend as if it contained any air whatever. On the contrary, if the blood in the pulmonary artery be treated in the ſame way, it evidently ſeems to be in a ſtate of ſeparation; the veſſel ſwells, and, if it be opened, a quantity of gazeous matter immediately evaporates.

CHAP. V.

OF THE MEANS BY WHICH THE BLOOD IS DISTRIBUTED FROM THE LUNGS TO THE DIFFERENT PARTS OF THE SYSTEM.

It proceeds from the lungs through the medium of four pulmonary veins to the left auricle and ventricle of the heart—from the left ventricle of the heart, it is conveyed into the aorta, and by various ramifications is diſtributed to the whole of the ſyſtem—the arteries deſcribed, &c. &c. &c.

ADMITTING that the lungs conſtitute the organs by which the blood becomes meliorated and improved, I think it juſt to conclude, that it is from them that its motion begins, and in which the true ſanguifying point conſiſts: the blood is conveyed from the lungs through the medium of four pulmonary veins, which gradually congregate together into one trunk, and enter the left auricle of the heart.

The heart is a large muſcular body, in ſhape reſembling a cone, ſituated in the thorax, between two laminæ of the mediaſtinum, and inveſted by a ſtrong membrane called pericardium,

dium, from which it is ſeparated by the medium of a fine fluid, which has received the appellation of liquor pericardii. Such is the increaſed aptitude to be moved which the blood acquires in conſequence of the vital air it receives from the lungs, that, as ſoon as the fœtal ſtate is ended, and the adult begun, the left ſide of the heart, which could not be found ab externo to move before, immediately pulſates, and that in a moſt rapid manner *.

As ſoon as the left auricle of the heart contracts, the cavity of which it is compoſed becomes immediately diminiſhed, and the blood with which it was filled is forced into the left ventricle, which at that moment is in a dilated ſtate: the left ventricle is ſeparated from the left auricle by the medium of the mitral valves; the fringes of theſe valves are

---

* As ſoon as the increaſed contraction of the left auricle of the heart takes place, the foramen ovale begins to cloſe, by the increaſed preſſure which the valve ſuſtains: it is by the mechanical preſſure which the blood produces on the valve, that the direct paſſage of the blood from the right to the left auricle gradually diminiſhes, and the valve becomes converted into a perfect ſeptum.

tied to the internal ſurface of the ventricle by a number of tendinous filaments, called chordæ tendinæ. Theſe chords are attached to a number of fleſhy pillars, called carneæ columnæ: as ſoon as the ventricle contracts, the blood is prevented from regurgitating into the auricle, by the elevation of the valves; it is therefore forced into the aorta. The blood is prevented from regurgitating from the aorta into the left ventricle, by means apparently the ſame as it was from the ventricle back into the auricle. The valves that are allotted this office are three in number, and of a ſemi-lunar appearance. Although it is very true that a conſtruction of this deſcription does not fill very accurately the whole circumference of the aperture, the defect is ſupplied by means of three ſmall tubercular bodies, called corpora ſiſamoidea, by means of which the whole is perfected.

Of the Aorta.

As ſoon as the left ventricle of the heart ends, the aorta begins; it immediately gives out coronary branches that are diſtributed to the heart itſelf; it riſes upwards three or four inches, inclining towards the right ſide of the thorax; it then takes a very diſtorted courſe towards the left, forming what is called its great curvature or arch. It is from the convex ſide of this arch, that three arteries of very conſiderable magnitude have their origin, and which are diſtributed to the ſuperior parts of the ſyſtem: the trunk of the aorta then bends downwards, and is called aorta deſcendens, touching in its courſe the left ſide of the ſpine.

Whilſt the aorta continues within the thorax, it ſends off in the firſt place veſſels that are immediately deſtined to convey blood for the nouriſhment and ſupport of the lungs; they are generally three or four in number, and are called bronchial arteries. The bronchial arteries are very intimately diſtributed upon the ſubſtance of the lungs, following the courſe of the bronchiæ, and extend as far as the trachea itſelf, ſending off twigs alſo to the œſophagus*.

Below

---

* A great variety frequently occurs in the origin of different arteries, and in none perhaps more than in thoſe I have juſt deſcribed. Although they for the moſt part

ariſe

Below the part where the bronchiæ ariſe, the aorta ſends off five or ſix ſmall twigs called arteria œſophagea, from the organ on which they are diſtributed.

As the aorta proceeds in its courſe downwards, it gives out ſeven or eight arteries on each ſide, at the interval of each vertebra: each of theſe arteries thus proceeds along a ſpace which is particularly formed for that purpoſe, at the inferior edge of each of the ribs, giving out an immenſe number of ramifications to the intercoſtal muſcles, and contiguous parts, as far as the ſternum itſelf.

After the aorta has given out theſe different veſſels, it paſſes under the arch which is formed by the crura of the diaphragm, ſending off two branches to the diaphragm itſelf called the phrenic, and, proceeding along the left ſide of the ſpine, enters the cavity of the abdomen.

After the aorta has entered the cavity of the abdomen, at the eleventh vertebra of the back, it gives out from its anterior portion an artery, which is enveloped, as it were, by the leſſer

---

ariſe from the aorta, it occaſionally happens that they proceed from the mammary, and ſometimes from the intercoſtal.

curvature of the ſtomach : it is ſhort, but of conſiderable lateral dimenſion, and is called the cæliac: this large trunk divides into three branches; the firſt of theſe, which is called coronaria ventriculi, is in the centre of the three, and is in ſize larger than a crow-quill ; it riſes upwards, and inclines towards the pyloric or left portion of the ſtomach : before it reaches the pyloric orifice it divides into two branches, which are diſtributed by means of different ramifications to the whole of the ſtomach itſelf. It were tedious to trace the courſe which the different twigs generally take, and mention the parts on which they are ſpread.

The ſecond branch which the cæliac gives out is eſpecially diſtributed upon the hepatic ſyſtem, and is conſequently called the hepatic artery : the hepatic trunk, after paſſing under the ſtomach, ſends off two veſſels to that organ, one to the right portion, and which is called gaſtrica dextra ; another to the left, called pylorica : the hepatic artery ſupplies alſo the pancreas and duodenum with a conſiderable branch before it reaches the liver ; and after it has entered the fiſſure of the liver, it becomes

encloſed

encloſed in Gliſſon's capſule, and then divides into two branches: the right branch paſſes under the biliary duct and, after ſupplying the gall-bladder with a cyſtic branch, enters the right lobe of the liver. The left branch, which is the ſmalleſt of the two, enters the liver at the foſſa umbilicalis, ſupplying in an eſpecial manner the left with blood.

The third and laſt branch which proceeds from the cæliac trunk is called the ſplenic, and is by far the largeſt of the three; it is as large as a large gooſe-quill: it proceeds at right angles, and, after purſuing a very diſtorted courſe, paſſes along the upper edge of the pancreas, upon which it beſtows different branches: nor upon the pancreas alone does it diſtribute veſſels before it reaches the ſpleen; it ſupplies the large extremity of the ſtomach alſo with a conſiderable branch called gaſtrica ſiniſtra.

As the ſplenic artery runs cloſe along the great curvature of the ſtomach, it ſends off four or five branches to that part, called *vaſa brevia:* the remaining trunk of the ſplenic artery either paſſes in an undivided courſe and enters the ſubſtance of the ſpleen, or occaſionally divides into ſeveral branches before it reaches that organ.

Of the Superior Meſenteric Artery.

The ſuperior meſenteric artery ariſes from the aorta, about half an inch below the cæliac: the origin of the trunk is ſituated in common with the cæliac, between the crura of the diaphragm; it then paſſes under the pancreas, ſending off a branch to the large extremity of that organ; and after penetrating the meſocolon, it proceeds to the meſentery itſelf, between the laminæ of which it becomes included; it then forms a kind of arch, turning firſt to the left, and by a gradual contortion to the right again, goes a conſiderable way down the abdomen before its ramifications begin. There are ſixteen branches or more that ſupply the inteſtines alone: ſuch is the frequent communication theſe veſſels have with each other, that they form a complete net-work on the meſentery, before their termination on the inteſtinal canal.

Of the Emulgent Arteries.

A little below the ſuperior meſenteric artery, the aorta gives almoſt at right angles theſe arteries, and which are diſtributed to the kidneys; they are ſhort and thick, and as ſoon as they reach the concave ſide of the kidneys each of them divides into three or four branches, and which enter the ſubſtance of the kidney itſelf; they have frequent anaſtomoſing with each other: the exhalant outlet they poſſeſs, terminates in the papillæ uriniferæ, where the fluid they effuſe is changed into an urinous ſtate: ſmall branches from theſe veſſels are diſtributed upon the capſulæ renales, and upper portion of the ureters.

The Inferior Meſenteric Artery

Ariſes from the anterior portion of the aorta, conſiderably below thoſe I have juſt deſcribed. It ſoon divides into three or four branches; one of theſe anaſtomoſes with the branches of the ſuperior meſenteric artery, completing the meſenteric arch; other branches are diſtributed upon the colon, and ſupply that viſcus with blood.

After the trunk of the inferior meſenteric artery has given out theſe branches, it is ſtill of conſiderable magnitude, often as large as a common writing quill. It turns in an oblique manner over the pelvis, and proceeds the whole length of the poſterior part of the rectum, until its termination at the anus, and is called the *hæmorrhoidal artery.*

The *Lumbar Arteries* ſeem to perform the ſame office in the loins the intercoſtal do in the thorax: they proceed in five or ſix pairs from the poſterior part of the aorta: the upper of theſe arteries tends from the aorta at right angles, the lower one has a ſmall inclination downwards: each lumbar artery gives out, like each intercoſtal, two principal branches, one of which goes to the ſpine, ſupplies the vertebra, and paſſes into the ſpinal marrow itſelf; and another branch, which is diſtributed by the medium of its ramifications upon the muſcles of the back and loins.

Of the Arteries of the Pelvis.

When the aorta has reached the fourth vertebra of the loins, it bifurcates into two equal trunks, giving off from the middle of the bifurcation an artery which is called *arteria ſacra media*; it proceeds ſtraight down over the projecting point of the ſacrum, as far as the ultimate termination of the os coccygis, giving in its courſe different branches, which go off in lateral directions, the fibres of which inoſculate with the arteries with which thoſe parts are more immediately ſupplied.

The aorta then loſes the name it formerly aſſumed, and the two trunks are known by the appellation of the iliacs. The two iliac arteries progreſſively diverge from each other, in a lateral direction, ſo that when they have reached the brim of the pelvis they are found at the part where the ſacrum and haunch bones are united. After the two great trunks of the iliac arteries have paſſed below theſe parts, each of them ſeparates itſelf into two. One of theſe (on each ſide) is called the internal, and the other the external iliac.

The internal iliac, or hypogaſtric artery, is of conſiderable magnitude, more eſpecially in the fœtal than in the adult ſtate. It is the trunk of each of theſe arteries, which in the fœtal ſtate conſtitutes the means by which the blood is returned from the fœtal to the maternal ſyſtems: after turning low down into the pelvis with a large circle, they riſe again by the ſides of the bladder, and aſcend towards the umbilicus, which they paſs through, forming the umbilical arteries. Soon after the infant is born, theſe arteries become obliterated, and merely exiſt in the form of a ligamentous ſubſtance.

It is the arch which I have above deſcribed that gives to the internal iliac artery a convexity in its inferior part, and from whence different arteries immediately proceed: ſome of theſe ſupply the different pelvic viſcera, the ſexual and generating organs * of both ſexes alſo, and which are called by the name of the organ or part upon which they are diſtributed.

The other branches of this artery, and which are four in number, paſs out of the pelvis and ſupply the glutæi muſcles, &c. &c. with an abundant quantity of blood †.

---

* The veſſels that ſupply the generating and ſexual organs have been already deſcribed.

† It would be ſuperfluous in this place to give a further account

The different parts of the machine that are ſupplied with blood from the various arteries I have deſcribed, (with a few exceptions only) are eſpecially deſtined by the actions they perform to preſerve the machine in a healthy ſtate, and to reſtore the loſs it ſuſtains in conſequence of the various voluntary actions it is made to perform: on the contrary, the other veſſels I am now to deſcribe are for the moſt part deſtined to nouriſh parts that are ſubſervient to the energy of the will, and which conſtitute in fact voluntary parts; for, whether thoſe arteries are diſtributed to bones, to tendons, or muſcles, the final cauſe in them all is the ſame—bones being deſtined to form attachments to tendons, tendons to muſcles, and muſcles themſelves conſtituting the moving inſtruments by means of which the energy of the will is diſplayed, and on which it is particularly exerted.

---

account of the ſpermatic artery: it ariſes from the lateral parts of the aorta a little above the lower meſenteric artery.

The External Iliac Artery

Paſſes by the brim of the pelvis along the edge of the pſoæ muſcles, through Poupart's ligament into the thigh, aſſuming the appellation of femoral artery. Juſt before the femoral artery has paſſed through the ligament it gives out two branches: inſtead of following the courſe of the trunk from whence they are derived, they take a totally different one. One of theſe arteries, which runs to the internal edge of the ilium, ramifies on the oblique and tranſverſe muſcles of the abdomen, and anaſtomoſes with the lumbar arteries, is called circumflexa. The other branch is called the epigaſtric, aſcends on the internal part of the abdomen by the edge of the tranſverſe muſcle, and becomes placed upon the centre of the recti muſcles, and finally inoſculates with the internal mammary artery.

The femoral artery, inſtead of ſeparating into different branches, ſends off a conſiderable branch only, called arteria profunda, about three fingers breadth from the ligament: it is the different ramifications that proceed from this trunk which ſupply the various muſcles eſpecially ſituated on the upper part of the thigh.

The femoral artery, after this ſeparation, follows the inclined courſe of the ſartorius muſcle by which it is covered; it then becomes ſo ſuperficially ſituated, that the pulſation of it ab externo may eaſily be felt, being covered by the common ligaments and the faſcia of the thigh alone. It then perforates the triceps muſcle about the diſtance of two hands breadth from the knee joint, and bending downwards gets under the ham, where it loſes the name of femoral, and obtains that of popliteal.

Of the Popliteal Artery.

The popliteal artery therefore begins where the femoral ends, and muſt be conſidered as a continuation of it. It lies upon the poſterior and inferior extremity of the thigh bone, and paſſes down betwixt the hollow which is formed betwixt its condyles; from the ham the popliteal artery deſcends into the leg, under the heads of the gaſtrocnemii muſcles, and divides below the joint under the head of the tibia into three great branches.

The firſt of theſe, which paſſes behind the tibia, is called poſterior tibial; the ſecond, after perforating the interoſſeous ligament, advances along the fore part of the tibia, and is called tibialis antica; and finally, the third, which paſſes down behind the fibula, is called by the common name of fibular or peroneal artery. It is from the elongated ramifications of theſe different trunks that the foot and toes are ſupplied with blood.

In proportion as theſe arteries proceed farther from the heart they become more muſcular in their fabric, and propel the blood they contain, more perhaps by the inherent powers they poſſeſs, than from the force with which the blood is moved by the contraction of the left ventricle. Such, however, is the admirable contrivance of theſe parts, that in proportion as the auricle dilates to receive the blood from the pulmonary vein, the ventricle contracts to propel the blood it contained, and force it into the aorta : and again, in proportion as the auricle contracts with a view of forcing the blood into the ventricle, the aorta contracts, and propels the portion of blood it had already received, and conveys it into the different veſſels I have deſcribed. That the power of the ventricle muſt exert conſiderable influence on the blood near to it muſt be readily allowed; the arteries therefore proceed from the aorta at right angles near the heart, and at acute angles as they recede from it; and when they receive leſs advantage from its action, from the local determination of blood that we frequently behold from a mere bluſh in the cheek to the diſtenſion of the penis, we muſt be led to conclude that the veſſels have of themſelves a local power of action independently of the heart; and that their action is frequently increaſed, whilſt that of the heart continues the ſame.

After having followed the courſes of the aorta deſcendens, and pointed out the various branches it ſends off for the nouriſhment of the various organs that ſupport the ſyſtem in general, and to thoſe organs that are ſubſervient to the energy of the will in particular; it is now neceſſary to point out the mode in which the veſſels that proceed from the curvature of the aorta are diſtributed. It is from the convex ſide of the curvature which the aorta deſcribes, that three arteries of conſiderable magnitude ariſe, and that are eſpecially deſtined to convey blood to the upper

per part of the ſyſtem: the firſt of theſe forms one common trunk; it has not, however, proceeded more than an inch from its origin before it divides into two, one branch of which is called the right carotid, and is diſtributed to the right portion of the head in gegeral; the other is called the right ſubclavian, ſo called from its ſituation under the clavicle.

It divides and ſubdivides into different branches, which ſupply the pericardium and mediaſtinum, the thymus and trachea. As the trunk of the ſubclavian artery aſcends immediately above the firſt rib, it loſes the name of ſubclavian and obtains the appellation of *Axillaris*, from the axilla through which it is to paſs.

The Axillary Artery

Sends off four conſiderable branches to the ſuperior part of the thorax, called thoracica ſuperior; to the mammæ in general, but more eſpecially to the external portion called mammaria externa; and finally to the axilla, ſcapula, and parts contiguous; from whence thoſe veſſels derive their name. After the axillary artery has given out theſe branches, it paſſes behind the tendon of the pectoralis major onwards to the arm, and then obtains the name of arteria brachialis.

The Arteria Brachialis,

In paſſing under the biceps muſcle, ſends off different ramifications to the contiguous parts; and when it has proceeded within two inches of the elbow joint it divides into two branches, one of which running along the bone of the fore arm is called ulna, and the artery is conſequently called ulnaris. The other artery, which is called radialis, follows the courſe of the radius. It is by the different ramifications which immediately proceed from theſe trunks, and by the infinite number of twigs that proceed from theſe ramifications, that the hands and fingers are ſo abundantly ſupplied with arteries, conveying blood for their nouriſhment and ſupport.

The left *ſubclavian* artery ariſes, like the right, from the arch of the aorta alſo; but inſtead of proceeding from one common trunk with the carotid, it ariſes ſeparate and diſtinct. Although its origin is different, the mode of its diſtribution is the ſame*.

---

* It has been ſuppoſed by ſome, that the reaſon why people in general were leſs alert or more awkward with the left arm than with the right, proceeds from the blood having from the aorta to the left ſubclavian artery a more indirect courſe, than it has through the right; ſo that the reſiſtance in the paſſage of the blood from the aorta is more conſiderable in the one than it is in the other; and conſequently that there is a leſs quantity diſtributed to the left than to the right ſuperior extremity. That there is not a more abundant quantity of blood diſtributed to the right than to the left arm in conſequence of this mode of conſtruction is evident from this, that if the area of the united trunk of the right ſubclavian and carotid, is leſs than the ſeparate trunk of the left ſubclavian and left carotid; it is more probable that the difference in ſize ariſes from the difference in the influence which the contraction of the left ventricle produces ſeverally upon them; but that the quantity of blood conveyed by them is much the ſame. That people in general employ the right rather than the left hand, is a matter of habit ariſing probably from imitation; and that they are more dexterous with the one than with the other, proceeds from additional experience, and the conſequent aptitude the muſcles poſſeſs to obey the dictates of the will. At a time like this, when a total change of manners and eſtabliſhed cuſtoms is ſought, the faſhion will come when the left arm will be more generally uſed, and therefore become more

Of the Carotid Arteries.

They are two in number: the right, as I have ſaid before, ariſes from the aorta in one common trunk with the ſubclavian; and on the contrary, the left carotid ariſes ſeparate and diſtinct from the trunk of the left ſubclavian: the ramifications of the right are deſtined to ſupply the right ſide of the head, as the left are deſtined to ſupply the left.

The trunks of the carotid arteries mount upwards upon the neck by the ſide of the trachea, where the pulſatory motions may be diſtinctly felt: after they have reached the angle of the lower jaw, each of the trunks divides into two; the external branch, which is called the external carotid, ſupplies the larynx and face—the ſcalp—and ſome of the fibrils penetrate the cranium, and are diſtributed upon the dura mater itſelf. On the contrary, the other branch which the trunk of the carotid artery gives out, ſupplies the internal parts of the head, and is conſequently called the internal carotid.

The internal carotid artery proceeds as far

---

more dexterous than the right, notwithſtanding the leſs quantity of blood it is pretended it receives.

as the inferior orifice of the pars petroſum of the temporal bone; and after following the tortuous courſe of the different parts through which it is to paſs, it enters the cavity of the cranium on the ſide of the ſella turcica, ſending off a branch to the orbit of the eye, which anaſtamoſes with ſome of the fibres which the external carotid diſtributed upon that organ: the trunk of the internal carotid proceeds under the baſis of the brain at each ſide of the infundibulum, and then divides into three branches; the firſt of which ſupplies the anterior, the ſecond the middle, and the third the poſterior lobe of the brain.

Conſiderable as theſe arteries certainly are in point of magnitude, the brain is not ſupplied by them alone; there is a large branch that proceeds from the ſuperior and poſterior part of each axillary artery; and becauſe they paſs through the tranſverſe proceſſes of the vertebræ of the neck (the ſixth or ſeventh) they have received the appellation of vertebral arteries. Theſe arteries, after going through the great foramen of the occipital bone, enter the cranium. After the vertebral arteries have entered the cranium, they approximate each

other,

other, and ultimately unite, forming one common trunk, called the baſilary artery. It is wonderful to behold the proviſion which Providence has made, by the great number of contortions which theſe different veſſels ſuſtain, to weaken the impetus of the blood they convey. It is not only weakened by this means. The internal carotid arteries, as they proceed by the ſide of the ſella turcica, are ſurrounded and involved in a ſpongy ſinus, ſomewhat ſimilar to the corpora cavernoſa, producing *perhaps* a retardation in the motion of the blood, by affording a great dilatation to theſe veſſels. After the arteries have perforated the dura mater, inſtead of plunging into the ſubſtance of the brain, they attach themſelves to the pia mater, to that delicate and tranſparent membrane by which the brain is immediately inveſted, and which lines the different lobes in the various convolutions and diviſions they form.

The arteries which are diſtributed to the brain are not only remarkable for the minuteneſs of their diviſion, but they differ in their fabric from the exhalant termination of other arteries in general. Other arteries commonly become more muſcular as they recede from the heart, in order that they may propel the blood by the inherent power they poſſeſs. On the contrary, the different arteries which are diſtributed to the brain, either become deſtitute of their muſcular coat, or at leaſt it is generally ſuppoſed to be much weaker than it is in other parts: theſe arteries are ſo extremely delicate in their fabric, that they become perpetually lacerated and torn by the force of a very weak injection.

Various attempts have been made to eſtimate the relative quantity of blood that was diſtributed to the brain. If the area of the aorta be meaſured, and compared to the united areas of the internal carotid and baſilary arteries, the proportion will be found to be as one to three and a half: although this mode of meaſurement will not give in the quantity of blood actually conveyed, it is in point for me to ſay, that none have ſuppoſed that leſs than a tenth part of the whole maſs of blood was ſent to that organ; many have rated it at a ſeventh; and others again, as high as a fifth of the whole.

Mr. John Bell, whoſe authority as an anatomiſt muſt certainly be conſidered of weight, eſtimates it at a fifth *.

I have however, by the able aſſiſtance of Mr. Cooper, aſcertained with the greateſt preciſion the area which the trunk of the internal carotid and vertebral arteries bear to the aorta deſcendens:

Aorta deſcendens, $1\frac{7}{8}$ inch in diameter.
The two external carotids $\frac{6}{8}$ of an inch.
The left ſubclavian $\frac{7}{8}$.
The right ſubclavian 1 inch.
The internal carotids $\frac{5}{8}$ each.
Each vertebral artery $\frac{1}{6}$.

It would therefore appear, that the quantity of blood conveyed to the brain is to the quantity of blood carried to the other parts of the body, as 13 to 36—or nearly as 1 to 3.

Of the Brain.

It will ſuffice for me to ſay, that the maſs of matter which is enveloped by the membranes which the cranium encloſes has received the appellation

---

[*] I muſt refer the reader for a very elaborate and particular account of the vaſcular ſyſtem, to the work he has lately publiſhed upon that ſubject.

appellation of brain. The portion of the brain which occupies the ſuperior part of the inſide of the cranium, is called cerebrum. The external part of the cerebrum is of a greyiſh colour, and called the cortical part: the internal portion, which is white, is called the medullary. The cerebrum is divided longitudinally into two hemiſpheres, and each hemiſphere into three lobes; the anterior lobe is ſituated on the orbiter proceſſes of the os frontis: the middle lobe is placed in the middle foſſæ of the baſis of the cranium; and the poſterior one reſts in the tranſverſe ſeptum.

Although the proportion of blood which the brain receives is vaſt and abundant, and far greater than what is allotted to any other part, the ſubſtance of the brain itſelf does not diſplay any preternatural appearance of vaſcularity or of ſanguification. This ariſes from the infinite minuteneſs into which the different ramifications divide. Such indeed is the tenuity of theſe veſſels, the tranſparency and exility of the fluid they encloſe and depoſit, that they conſtantly elude the enquiries and reſearches of the anatomiſt.

Where the maximæ fibrillæ are ſo ſmall, how exquiſitely minute muſt not the minimæ fibrillæ actually be, and how ſubtle the fluid they depoſit *!

It cannot be otherwiſe in a machine which is formed with the moſt exquiſite ſymmetry and order, in which there is conſent between all the parts, in order that harmony may be the reſult of the whole. It is with a view to the preſervation of this harmony, that a mu-

---

* Although various parts of the brain in an healthy ſtate do not diſplay any appearance of veſſels, we frequently find them apparent in thoſe parts, in conſequence of the red particles of blood that are forced into them by the increaſed action that takes place during the progreſs of inflammation.

That the ſubſtance of the brain is ſupplied with blood veſſels and with blood, is proved from hence, that pus is occaſionally formed within the brain itſelf. I remember to have diſſected a man who died of this complaint: he was ſeized at firſt with ſymptoms of phrenitis; as the inflammatory ſymptoms went off, a perfect hemiplegia took place, with a conſtant pain in the left ſide of the head. He continued in this ſtate ſome time, and died. On opening his head, I found the membrane bearing the marks of previous inflammation; within the left lobe of the brain itſelf, near an inch from the pia mater, a circumſcribed abſceſs exiſted, containing half a tea-cupfull of as perfect pus as ever I have ſeen.

tual correſpondence is found to ſubſiſt in the organization of the parts that are deſtined to perform a joint and co-operative office.

The cerebellum is ſituated on the poſterior part of the cavity of the cranium; it has within its ſubſtance different furrows, which run nearly parallel to each other; into which folds of the pia mater penetrate, and upon which different fine veſſels enter, and ſupply it with blood. Below the cerebellum, and at the poſterior part of the cranium, the medulla oblongata exiſts: it is a continuation of two conſiderable proceſſes which the cerebrum gives out, called the crura, and of two large proceſſes of the cerebellum. And finally, the medulla oblongata ends in the medulla ſpinalis, which paſſing through the great foramen of the cranium, occupies the whole of that long canal which is formed by the different vertebræ. The ſpinal marrow, like the brain, conſiſts of a medullary and of a cortical part, differing from it alone in the mode in which each part is arranged: inſtead of the medullary part being placed without, and the cortical within, the cortical part is placed within, and the medullary one without. The ſpinal marrow, in common with the brain, is internally lined and protected by the ſame membranes, paſſing together through the great occipital foramen *.

So important is the brain, that any the leaſt deviation from its healthy ſtate is always attended with very deleterious and often with fatal effects to the ſyſtem at large. It does not, however, appear ſo important either in the fœtal or infant ſtate as in the more advanced periods of manhood and of old age. The evolution of the fœtus ſometimes takes place without any brain whatever; and I have been credibly informed, that in ſome laborious caſes of parturition, where the cranium has been perforated and a portion of the brain abſolutely evacuated, reſpiration has taken place, and the infant been heard to cry as ſoon as it has been expelled.

* There are various ſubſtances which exiſt within the parts I have deſcribed, called by particular names, which ſeem to perform a glandular office, and others again that would ſeem to ſerve as reſervoirs for the fluid ſecreted; but as we are totally ignorant of the uſe of every one of theſe, I muſt refer the reader to different anatomical works, where he may find an accurate and particular deſcription of the appearances which the brain diſplays upon diſſection.

Neither does it appear that external injuries inflicted on the head are equally dangerous in their nature or conſequences in the infant, as in the more adult periods of life; whether ſituated in the anterior and ſuperior parts of the head, or on the poſterior and inferior ones. I have had ſeveral young patients under my care, where there has been, from external force impreſſed upon the ſkull, an evident and well-marked fracture, with depreſſion, where no bad ſymptoms ever manifeſted themſelves, and where no other means were employed than evacuation and reſt.

The ſame accident happened to a gentleman under my care, where the os frontis was fractured and conſiderably depreſſed, in conſequence of a fall from his chaiſe. As no bad ſymptoms appeared, I merely bled him freely, and uſed other evacuations: an exfoliation took place of both laminæ of the bone; but he perfectly recovered, and has continued well ever ſince, and that is now four years ago. I mention theſe caſes with a view of cautioning practitioners from the indiſcriminate uſe of the trephine, which has been perhaps too ſtrongly recommended by Mr. Pott, and from the ſtrength of his authority too generally employed. There have been lately a number of caſes publiſhed by Mr. Abernethy, the ingenious pupil of Mr. Pott himſelf, where ſimilar caſes are related, of perſons who perfectly recovered without the trepan.

I have known a conſiderable portion of the parietal bone chipped off by a ſtroke from a broad-ſword, and the dura mater laid bare, without the patient having ſuſtained any particular inconvenience, and where no more was done than merely applying a ſuperficial dreſſing to the wound. On the contrary, I have ſeen the ſame accident happen, where the trephine was employed, although the man was perfectly ſenſible; but where the event terminated fatally.

I ſhall conclude theſe obſervations by relating one of the moſt extraordinary caſes of recovery perhaps that has ever occurred. I witneſſed the whole progreſs from the moment the man received the injury to the completion of the cure: he was under the judicious care of my friend Mr. Walters, a ſurgeon on the ſtaff in Guernſey, where the accident happened.

Caſe.—James Clark, a ſoldier in the 83d regiment of infantry, whilſt he was at exerciſe had his ſkull fractured by a portion of the barrel of a muſket, which burſt whilſt it was firing off. The portion of the muſket ſtruck the os frontis immediately over the left frontal ſinus, ſhattering the bone in a very extraordinary manner. The fracture extended obliquely through the inferior part of the frontal bone where it joins the oſſa naſi, proceeding into the right orbit of the eye. It appeared that the falciform proceſs was lacerated, becauſe the finger could be paſſed without any obſtruction from one ſide of the os frontis to the other; and ſuch was the fountain of blood that was immediately diſcharged, that it was equally obvious that the longitudinal ſinus had been lacerated, and that the hæmorrhage came from that ſource alone. The fracture, which was not only moſt formidable from its extent, became even more terrible from the vaſt comminution of bone; there were many ſplinters evidently broken, and preſſing on the left anterior lobe of the cerebrum, and others again that had lacerated both the dura and pia mater, and penetrated the ſubſtance of the brain itſelf. Such was the force by which they had been driven, that it was impoſſible to remove them without firſt taking off a portion of the ſuperior part of the os frontis, including a part of the frontal ſinus: to effect this purpoſe, recourſe was immediately had to the trephine, and the end was attained: he was then dreſſed ſuperficially; and as he had loſt a conſiderable quantity of blood from the head, it was not thought adviſable to take any from the arm.

During the whole of this interval the patient preſerved his intellect very perfectly, complaining occaſionally of conſiderable pain: for twelve hours more he continued correct, and the pain of which he complained received ſome mitigation from the effect of an opiate. The antiphlogiſtic plan was immediately adopted and purſued: he then became, and for three days continued delirious, accompanied with a conſiderable degree of fever. On the third day the dreſſings were removed, and the wound examined: more ſplinters were taken away; a firm hard ſubſtance was felt under one of them, projecting a little beyond the edge of the fractured bone. Upon a more minute examination, this ſubſtance was found to be the extremity of a piece of iron. Attempts were made to extract it with the common dreſſing forceps, but in vain; it was wedged in ſo cloſely, that it was neceſſary not only to employ the large trepanning forceps, but to uſe conſiderable force in the extraction before any impreſſion could be made upon it. A piece of the barrel of the muſket was at length extracted, exactly three inches in length; the convex part of which adapted itſelf to the concave ſurface of the internal portion of the frontal bone; it penetrated obliquely downward and inward, inclining ſomewhat towards the left ſide. It is probable, from the firm manner in which it was wedged, that it penetrated the left alar proceſs of the ſphenoidal bone. During the period that it was removing, the internal ſurface of the barrel was found to contain a quantity of the anterior lobe of the cerebrum; and it appeared that three tea ſpoonfulls altogether were diſcharged.

The patient found himſelf much relieved after the head had been releaſed from all this extraneous matter, and he continued with very moderate ſymptoms for five days more.

On the ninth day he became comatous: he, however, recovered from this ſtate by the operation of an enema, that procured ſeveral motions, and he recovered his general health ſoon after in a very ſurpriſing degree.

The wound put on about this time a granulating ſurface. This however was not of long duration; for a very luxuriant fungus ſprouted up, and which aſcended to a conſiderable height. Mr. Walters, however, by the judicious application of the argentum nitratum (no preſſure was employed) deſtroyed the whole, and reduced it to a proper level, and in about two months from the infliction of the accident the man recovered—he recovered indeed ſo perfectly, that within a very few months (my notes do not ſpecify the time, although I recollect the fact) he was able to do his duty as a good ſoldier in the regiment.

Such was the violence of the ſhock, and the injury which the optic nerves ſuſtained, that he complained of blindneſs for the four firſt days: he ſoon recovered the ſight of the left eye; but the fracture having extended within the right orbit, the whole fabric of that eye appeared and continued inflamed for a conſiderable time, and he beheld objects from it in a manner very imperfect and very indiſtinct. He however recovered from this ſtate of imperfection, and got perfectly well.

Size of the Brain.

The magnitude of the brain with reſpect to the ſize of the body, and more eſpecially to the organs of ſenſe and of ſenſation, not only varies in different animals, but in the ſame animal at different periods of its exiſtence. The head bears a marked and increaſed ſize with reſpect to the ſyſtem at large; in the fœtal ſtate more than in infancy and youth.

Baron Haller, in a boy ſix years old, whoſe body weighed fifty pounds, found that the brain weighed two pounds three ounces and a half; ſo that it bore the proportion to the whole of 1 to 22. In an adult that weighed 146 lbs. 6 oz. he found the proportion to be as 1 to 30. In a ſecond, that weighed 140 lbs. his brain weighed 4 lbs. ſo that with reſpect to the body it was as 1 to 35: and in a third man who weighed 160 lbs. the brain weighed 4 lbs. ſo that the proportion was as 1 to 35.

Mr. Bell eſtimates the proportion as 1 to

40.

40. Theſe are certainly higher rated than I have done, having ſtated that it was as 1 to 50. The difference, however, may be eaſily reconciled, when we reflect on the different periods in which we may preſume theſe calculations were made. It is very eaſy for a man to loſe twenty or thirty pounds weight of his body in the progreſs of the diſeaſe of which he died. The brain, however, does not ſuſtain the ſame proportional loſs, as it ſtill continues to fill the cavity of the cranium; there is a ſource that is capable of producing a great variety, and that is adequate to reconcile the difference.

I have inſerted and arranged the relative proportion of the brain of different animals with reſpect to the ſize of the ſyſtem, which Dr. Rowley has collected from different authors, and which he has introduced in the Schola Medicinæ Univerſalis Nova, lately publiſhed. It ought to have been accompanied by an account of the ſize in the different organs of ſenſe and ſenſation, and the relation that exiſted between them particularly ſpecified. It is our ignorance in this reſpect that renders even our conjectures reſpecting theſe organs even more problematical than they would otherwiſe be.

Animals.	Weight of Body.				Brain.				Proport. to the Body.			Authors.
	℔.	℥.	ʒ.	gr.	℔.	℥.	ʒ.	gr.				
A Dog	0	0	0	0	0	0	0	0	1,154	1,88	1,54	Arlet.
An Ape	5	9	0	1	0	0	16	90	1	to	11	Buffon.
A Canary Bird	0	0	0	180	0	0	0	13	1	—	14	Pozzi.
A Sparrow	0	0	0	380	0	0	0	21	1	—	15	Ditto.
A Cock	0	25	0	0	0	1	0	0	1	—	25	Ditto.
An Ape	5	9	0	0	0	0	16	90	1	—	28	Buffon.
A common Mouſe	0	0	0	324	0	0	0	17½	1	—	43	Ditto.
A Dormouſe	0	0	23	0	0	0	0	28½	1	—	53	Ditto.
An Aſs	198	0	0	0	0	12	2	48	1	—	60	Ditto.
A domeſtic Mouſe	0	0	36	0	0	0	0	34	1	—	76	Ditto.
A Cat	0	76	0	0	0	0	7	24	1	—	82	Arlet.
A Goat	19	0	0	0	0	0	25	46	1	—	94	Ditto.
An Ape	5	9	0	0	0	0	16	90	1	—	107	Buffon.
A Rabbit	0	44	0	0	0	0	2	30	1	—	140	Arlet.
A Cat	8	0	0	0	0	0	6	32	1	—	156	Pozzi.
An Eagle	0	0	0	0	0	0	0	0	1	—	160	Borrich.
A Dromedary	369	0	0	0	0	15	0	0	1	—	216	Buffon.
A Hare	0	136	0	0	0	0	7	0	1	—	218	Arlet.
A Stag	161	0	0	0	0	11	5	0	1	—	221	Buffon.
A Wolf	64	0	0	0	0	4	3	4	1	—	230	Ditto.
A Beaver	30	0	0	0	0	0	0	0	1	—	290	Pariſini.
A Dog	62	0	0	0	0	0	26	0	1	—	305	Buffon.
A Sheep	57	0	0	0	0	0	21½	0	1	—	324	Ditto.
A Gooſe	0	108	0	0	0	0	0	144	1	—	360	Haller.
A Beaver	17	0	0	0	0	0	6	0	1	—	362	Buffon.
A Horſe	400	0	0	0	1	0	0	0	1	—	400	Ditto.
An Elephant	5000	0	0	0	10	0	0	0	1	—	500	Ditto.
A Lion	243	0	0	0	0	5	10	8	1	—	615	Ditto.
A Horſe	700	0	0	0	0	28	0	0	1	—	700	Ditto.
An Ox	866	0	0	0	0	0	0	0	1	—	866	Ditto.
Ditto	1500	0	0	0	2	0	0	0	1	—	1154	Redi.
Galeus Piſcis	25	0	0	0	0	0	2	0	1	—	1200	Ditto.
Teſtudo terreſtris	2	4	0	0	0	0	0	6	1	—	2240	Caldeſi.
Canis Carcharius	26	0	0	0	0	0	0	0	1	—	2496	Steno.
Teſtudo Marinus	79	0	0	0	0	1-6	0	0	1	—	5688	Ditto & Redi.
Canis Carcharius	3000	0	0	0	0	1-3	0	0	1	—	12000	Steno.
Tunny Fiſh	390	0	0	0	0	0	1	0	1	—	37440	Redi.

The Brain conſidered as a Secretory Organ.

When we reflect on the number of veſſels that are diſtributed to the brain, and on the quality of the fluid they convey, the queſtion naturally preſſes itſelf upon the mind, why ſo large a quantity of blood is beſtowed upon that organ, and what is the uſe for which it is eſpecially deſigned? Anatomy furniſhes us with no means of ſolving the queſtion; analogy alone conſtitutes the reſource to which we can appeal; analogy teaches us, that the blood which is conveyed by different veſſels, and depoſited from their open extremities into different ſecretory organs, is changed by virtue of the power which thoſe organs poſſeſs, and qualities imparted to it of which it was deſtitute before: thus it is that we have the blood changed into bile by the action of the liver, into pancreatic juice by the power of the pancreas, into ſemen by the power of the teſtis. Why then ſhould we deny to the brain the ſame office, however different it may be from them in the mode of its conſtruction? I think we are warranted from analogy, and from the neceſſity of the caſe itſelf, to conclude, that the brain is a gland, like thoſe I have mentioned, poſſeſſing within itſelf the power of ſeparating from the ſubtle fluid which the veſſels depoſit, (I might almoſt call it the immaterial fluid) a particular part from the whole, to which ſpecial and ſpecific qualities are imparted.

To what portion of the brain this province belongs, is not for me to proclaim: the medium is too groſs through which our organs muſt examine it: the powers of our organs are too limited in themſelves, and the organization of the brain is too minute for the exquiſite delicacy of its fabric to be aſcertained.

Aware, I preſume, of this difficulty, Profeſſor Harwood judiciouſly obſerves, and with elegance expreſſes, "that when we diſſect the brain, and obſerve the different ſubſtances of which it is compoſed, and their different forms; Imagination, aſſuming the office of Reaſon, would willingly aſſign a peculiar uſe to every part, and pronounces one to be the reſidence, or rather the inſtrument of memory; another of abſtraction, a third of volition, &c. When a ſenſation is excited by the action of any ſubſtance upon the body, we immediately perceive upon what part of the body the ſubſtance acts, where the impreſſion begins; and as the impreſſion is conveyed by the nerves to the brain, it is conceivable, that we might have been ſo conſtituted as to perceive with the ſame facility in what part of the brain the impreſſion ends. This, however, experience convinces us, we are not able to determine."

In what manner the energy of the will is imparted to the brain, is a ſubject we ſhall not enter upon: the manner in which the energy of the brain is communicated to the nerves has had ſome light thrown upon it by the different experiments of Galvi, Galvani, Dr. Fowler and others. Theſe experiments lead us to believe, that the nerves contain a ſubtle fluid, ſomewhat ſimilar to the electric fluid, and that it is the mean through which the various impulſes are conveyed from the brain to the different parts of the ſyſtem, and back again from the different parts of the ſyſtem to the brain.

The diſcovery was made by Galvani, Profeſſor of Anatomy at Bologna, by mere accident: if it had been by deſign, and if any merit could have attached to him for ſcientifically inveſtigating a ſubject, any diſcovery that he might have made would have been darkened and diſgraced by the mode he adopted. This man, it ſeems, had hooked a number of poor frogs by the back bone to the iron palliſadoes of his houſe, and he was much ſurpriſed to ſee the different muſcles of theſe poor animals thrown into different contractions: he found alſo, that he could produce the ſame effect by applying different metals at the ſame time to different parts of the ſame animal.

It appears very probable, that it is this ſubtle fluid which has been received by the act of inſpiration (and which afterwards forms one of the conſtituent parts of the blood) which the brain ſeparates from the reſt; that it is this ſubſtance that conſtitutes the ſubject matter by which the ſentient principle is received, and in which it is made to abide. It is through this ſubſtance which the nerves contain, that irritability is imparted to the muſcular fibre, conveying ſenſation and motion to every part of the ſyſtem. In ſome experiments that I have ſeen performed upon a frog, by ſtripping the ſciatic nerve, and coating the extremity of it with a piece of tin foil, and holding the animal by the other limb; as ſoon as a ſilver probe was applied ſo as to form a circuit between the ſciatic nerve, coated by the tin foil, and the other extremity of the nerve reſiding in the toe, the whole limb was thrown into convulſions: theſe convulſions however progreſſively diminiſhed, and ceaſed altogether in proportion as the metal was repeatedly applied. The ceſſation of theſe motions appeared to me to proceed from the fluid having been totally conducted away from the nerve by the metal, ſo that, the cauſe (the fluid) through which the irritability was imparted being exhauſted, a perfect paralyſis enſued *.

Of

---

* It muſt not however be ſuppoſed that this fluid, whether it be the electric fluid or caloric, which I think more probable, when it exiſts in the blood or in the nerves of a living animal, exiſts in the ſame form as it does in a common ſtate: either of theſe different ſubſtances are prevented from exerting their own ſenſible or chemical properties on the living ſyſtem, by the aſſimilating power of the organ through which they are received: although they may exiſt in a ſenſible form out of the ſyſtem,

Of the Nerves.

However ignorant we may be as to the particular parts which are eſpecially deſtined to receive the immediate energy of the will, the fact is notwithſtanding undeniable, that it is ſome portion of the brain to which this office is allotted; that the nerves are the agents through which it is conveyed to the muſcles; and that the muſcles themſelves are the inſtruments by which that energy is diſplayed.

That this is the fact is proved directly by the power we poſſeſs of moving particular parts according to the dictates of the will; and that the nerves are the agents through which thoſe dictates are conveyed, appears equally evident; for, if a nerve which goes to

---

ſyſtem, the inſtant they have been aſſimilated by the ſyſtem, their *ſenſible* properties become *latent*. They however recover their ſenſible properties, and loſe their latent, when the living power of the animal becomes weakened and exhauſted: it is then we ſee theſe various phenomena produced, but which could not be produced without læſion or violence. It is this ſubſtance which appears to be given as an excretory ſubſtance by the torpedo, by the gymnotus electricus, and other animals of the ſame claſs.

a voluntary part be tied or cut off, that muſcle becomes in a paralytic ſtate, and ceaſes to be under any voluntary controul.

Although the energy of the will is effectually aboliſhed in that part, the ſenſibility, or its inherent power of irritability and of ſpontaneous motion, continues in an unabated degree. This power of ſpontaneous motion frequently continues in particular muſcles for ſeveral days, after they have been completely ſeparated from every communication with the brain, or torn out from the ſyſtem itſelf, of which they formed a part. Hence ſeems to ariſe the apparent neceſſity of making a diviſion of the nerves, into thoſe ſubſervient to ſenſation independent of volition, and of muſcles that are moved by the energy of the will, from thoſe that act independently of its controul.

Of the Nerves of Senſe.

It appears to me that the nerves of ſenſe and of ſenſation as they have been called, poſſeſs powers and perform an office totally oppoſite and diſtinct from the nerves which are diſtributed to voluntary parts. The former have their origin from without, and terminate in the brain within; the latter ariſe from the brain within, and terminate in the parts without. The one are the immediate recipients of things *external* to the ſyſtem; the others are the agents that convey from the brain *within* the energy of its will. And finally, the nerves of ſenſe are excited by powers not only totally different from the nerves of voluntary motion; but the mind, by the power through which the nerves of volition are excited, has little or no influence on the nerves of ſenſe. The mind cannot prevent the impreſſion of different ſubſtances acting upon the ſentient nerves: of the guſtatory nerves, from feeling the impreſſion of ſapid bodies; the olfactory nerves, the flavour of volatile gaſes; the optic nerves, the images conveyed by the reflected rays of light; the auditory nerves, from feeling the ſounds excited by the vibration of ſonorous bodies; or, finally, the extremity of the ſentient nerves that ariſe from the whole ſurface of the cutis, from feeling the impreſſion inflicted by ſtripes. No effort of the brain, I ſay, can choke up theſe avenues, and prevent the nerves from receiving the impreſſions when they are made. Theſe organs of ſenſe and ſenſation are the proper media through which the impreſſions they receive are tranſmitted to the brain, as the immediate organ in which conſciouſneſs reſides.

What is the peculiarity in the conſtruction of the extremity of theſe nerves, by which they are ſuſceptible of receiving impreſſions ſo various and diſcordant, it is impoſſible for us to ſtate: their ſubſtance is firm and inelaſtic, and plentifully ſupplied with blood; theſe nerves appear to abound more in thoſe parts of the ſyſtem that are eſpecially deſtined to fulfil the final cauſe of animal exiſtence, more in the lip than in the face, more in the nipples than in the breaſts, more in the ſexual and generating organs in particular than in the neighbouring parts in general.

Of the Means by which the Nerves of Senſe are protected.

The external arrangement of the organs of ſenſe bears the ſame relation to the ſentient nerves theſe organs contain, as the mouth and teeth do to the ſtomach and lungs: the air received by the lungs is regulated in its temperature by the mouth and trachea, as the proper media through which it is to paſs. The food which the ſtomach receives is firſt prepared by maſtication and the addition of ſaliva; in like manner the external fabric of the organs of ſenſe fits the impreſſion which it receives from without to the nature of the nerve within; it modifies and accommodates the ſenſible properties of external objects, by means of which they become in harmony with the internal parts. And finally, it is owing to the different media through which the impreſſing cauſe is to paſs, that the ultimate changes are produced upon it; and that it becomes aſſimilated as it were to the nature of the nerve upon which it is deſigned to act. It is therefore neceſſary to give a curſory account of the different media which are allotted to perform theſe particular purpoſes.

The nerves of ſenſation that are diſtributed on the ſurface of the ſkin are protected by the cuticle, and a ſebaceous matter called rete mucoſum; the olfactory nerves, by the mucus which ſmears over the internal ſurface of the noſe, and the parts in general on which the nerve is diſtributed: the auditory nerve is protected by the external ear, by the cerous matter with which the tympanum is covered, by the tympanum itſelf, and the whole complicated fabric of the internal ear. The optic nerve is protected by the vitreous humour (improperly ſo called), a fluid of a moſt wonderfully lucid nature. This vitreous humour is contained in a tunic which divides it into different cells, like the parenchyma of an orange. The vitreous humour is protected by the cryſtalline lens, a ſubſtance more ſolid and denſe. The lens itſelf is protected by the aqueous humour, a gelatinous but tranſparent fluid, which occupies the whole ſpace between the lens and tranſparent cornea; and finally, the whole is preſerved and protected externally by the cornea, a membrane of conſiderable ſtrength and reſiſting power.

Mr. Hunter ſuppoſed, "that the cryſtalline lens was compoſed of a ſubſtance of a laminated nature; that the different laminæ appeared formed of different fibres, which he thought were of a muſcular ſtructure, with a view of adjuſting the eye by their contraction and relaxation to different diſtances." Unfortunately for phyſiological ſcience, Mr. Hunter died before he could bring to a concluſion the different experiments which he had deſigned: the ſubject has however been proſecuted with great ability by his brother-in-law Mr. Home, aſſiſted by the very ingenious Mr. Ramſden. Mr. Ramſden does not immediately agree with Mr. Hunter: he ſays, "that the cryſtalline humour does conſiſt of a ſubſtance of different denſities, the central parts being the moſt compact, and from thence diminiſhing in denſity gradually in every direction; approaching the vitreous humour on one ſide and the aqueous humour on the other, its refractive power becomes nearly the ſame with that of the other two contiguous ſubſtances:—that ſome philoſophers have ſtated the uſe of the cryſtalline humour to be for accommodating the eye to ſee objects at different diſtances; but the firmneſs of the central part, and the very ſmall difference between its refractive power near the circumference, and that of the vitreous or the aqueous humour, ſeemed to render it unfit for that purpoſe; its principal uſe rather appearing to be for correcting the aberration ariſing from the ſpherical figure of the cornea, where the principal part of the refraction takes place."

Various experiments were made upon a man in St. George's Hoſpital, who was couched: from whence it appears that the eye has the power of adjuſting itſelf to different diſtances when deprived of the cryſtalline lens; and therefore that the fibrous and laminated texture of that lens is not intended to alter its form, but to prevent reflection in the paſſage of the rays through the ſurfaces or media of different denſities, and to correct ſpherical aberration.

The power therefore which the eye poſſeſſes of adjuſting itſelf, as it does, to different diſtances, does not proceed from any action in the lens: the power ſeems to ariſe from the four recti muſcles, whoſe action ſeems to be immediately under the controul of the will. The effect of their action does not ſeem to produce any change in the form of the globe of the eye; it ſeems to ariſe from the alteration which the curve of the cornea undergoes, varying the refraction of the rays, and altering thereby the focus of the eye.

The cornea on examination appears particularly ſuſceptible of undergoing this alteration by virtue of the elaſticity it is found to poſſeſs. One end of it was made faſt, by fixing the ſclerotic coat, and a force was applied to the other. The power employed was capable of elongating the cornea $\frac{1}{20}$ part of an inch, and on removing the force, the cornea recovered itſelf to its original length: in different trials it varied in the quantity of elongation, but in all of them it was fully $\frac{1}{11}$ part of the whole length or diameter of the cornea; and it further appeared, that the central part yielded more readily to the power applied than the edges. The cornea does not ſeem to be of an uniform thickneſs; it is thicker in the centre than in its circumference, and the difference ſeems principally to ariſe from the fabric of the external lamina; for, when it is removed, the parts below ſeem perfectly and uniformly ſmooth: that the cornea is of a laminated texture, Mr. Home diſcovered in diſſecting the muſcles to their termination*.

The external fabric of the organ is the medium between the external object and the nerve by which the impreſſion is to be received, as the nerve itſelf by which the impreſſion is received, is the medium between the brain, in which the impreſſion is depoſited, and the intelligent principle in which conſciouſneſs eſſentially reſides.

---

* Vide Firſt Part of Philoſ. Tranſ. for the Year 1795.

An Aptitude in the Impreſſing Cauſe neceſſary.

For fit impreſſions therefore to be received, it is neceſſary that the principle of life ſhould have properly evolved the different organs, not only of ſenſe but of conſciouſneſs alſo. When the external impreſſion is ſtronger than the external fabric of the organs can accommodate and fit, before it arrives at the nerve by which it is received; inſtead of being aſſimilated, if I may ſo ſay, by the media that are deſtined to perform this office, and through which the impreſſion is to paſs, it deranges the fabric of the whole—the impreſſion, inſtead of being amicably received in the part, produces confuſion altogether; pain and diſeaſe are the conſequences that enſue.

This is the effect that takes place when the eye is expoſed to too ſudden and too ſtrong a light; the ear to too ſtrong a ſound; and the olfactory ſenſe to volatile bodies too powerful in their operation; and the body itſelf to blows beyond its power of reſiſtance. On the contrary, if the impreſſion is too weak, it is loſt in the medium through which it is to paſs, before it can arrive at the nerve by which it is to be received as its proper recipient; either an imperfect impreſſion, or a total privation of it, is produced.

For a proper impreſſion therefore to be received, it is neceſſary that the impreſſing cauſe (the external ſubſtance) ſhould be ſuch a one as the nature of the organ demands, and of appropriate power for the external fabric of the organs to accommodate and aſſimilate. When theſe circumſtances concur, the impreſſing cauſe is then received by the nerve in a becoming and adapted manner: each organ therefore requires particular objects by which it can be excited: rays of light for the eye; the vibratory motion of the air for the ear; ſapid bodies in a liquid ſtate for the tongue; volatile bodies for the olfactory ſenſe. The impreſſions theſe reſpective bodies communicate through the organs to the nerves by which they are received, muſt correſpond to the nature of each; otherwiſe the effect

produced

produced is illuſory and void. For example, it is the province of the eye to receive impreſſions from the rays of light, but not from volatile bodies in general; of the ear, to receive impreſſions from the vibratory motions of the air, but not from denſe bodies; of the guſtatory ſenſe, to receive impreſſions from fluid, and not from ſolid and inſoluble ſubſtances.

Each organ therefore can only have a partial knowledge of any one ſubject, ſince that knowledge cannot ſurpaſs the limits of its organization, to the nature of which the impreſſing cauſe muſt be accommodated: it is therefore on the principle of life that organization depends as its cauſe; but it is by the eſſential and ſpecific powers which theſe nerves poſſeſs, that external impreſſions are received, and ſenſation in general is produced.

It is not the nerves of ſenſe alone that appear to be ſeparated and removed from the immediate power of the brain, but thoſe in general by which the thoracic and abdominal viſcera are ſupplied: the mind cannot command the heart to ſtop, the ſtomach to digeſt, the periſtaltic motion of the inteſtines to ceaſe, &

&c. &c. I have frequently ſeen the periſtaltic motion of the inteſtines continue in different animals after complete diſlocation of the cervical vertebræ, and even after decapitation itſelf. In turtles and in frogs I have known the heart to contract, not only after the animal had loſt its head, but after the heart itſelf had been completely ſeparated from its reſidence in the ſyſtem: and I have ſeen ducks fly and run for a conſiderable time after the head had been cut off.

The nerves with which theſe viſcera are ſupplied have a peculiarity in their ſtructure, very different from thoſe that are ſubſervient to the immediate energy of the will. This ſtructure conſiſts in a number of ſmall bodies, of a hard knotty appearance, called *ganglions*. Theſe *ganglions* are very varied in their ſtructure; ſome are like knots, others like knobs; ſome of an oblong form, and others again of a ſemi-lunar appearance. They are diſperſed with conſiderable uniformity in particular parts: they abound in thoſe nerves which are diſtributed to organs which are eſpecially removed from the influence of the will—as the pancreas and ſpleen—the heart—

ſtomach and inteſtines, &c. &c. &c. On the contrary, there are none in thoſe nerves which are diſtributed to muſcles of voluntary motion, or even to parts very remote from the brain or organ of conſciouſneſs—none in the extremities, &c. &c.

Dr. Johnſton, of Worceſter, has the merit of being the firſt, I believe, who has advanced a very probable idea with reſpect to their uſe. He conceives "that they are the inſtruments by which the motions of the heart and inteſtines are from the earlieſt period of life rendered uniformly involuntary; and that this is their uſe, which they ſubſerve by a ſtructure indeed unknown to us (yet evidently different from that which uſually obtains in nerves), no leſs than that of the brain, though it ſeems not improbable the firſt may have ſome analogy to the laſt *." And he finally concludes, "that as the great ſympathetic nerves are truly derived from the ſpinal marrow, which have in the numerous ganglions proper to them ſo many receptacles of nervous energy, ſo many ſubordinate brains, which continue to diſpenſe the nervous energy to the vital organs long after

---

* Page 17.

they ceaſe to have communicated with the brain; and ſupport the irritability of the heart, which makes it ſo long ſenſible to the ſtimulus of the blood flowing into its auricles and ventricles, after the reſt of the machine is in fact dead. But as the whole nervous ſyſtem derives its energy from, and ultimately depends upon the brain and cerebellum; theſe ſubordinate ſources of nervous energy being at length exhauſted, without the poſſibility of a new afflux from the brain, the vital organs at length ceaſe to move *."

Such is the ignorance which we all poſſeſs with reſpect to nervous energy, that I beg to have it underſtood, that what I have ſaid has ariſen from reflection on the ſubject, with as much attention as I was capable, but that I am very far from thinking it concluſive, or void of objection. I ſhall therefore feel very happy to modify my opinion, if new facts ſhould ariſe to prove it an erroneous one. I hope I ſhall not be guilty of arrogance, if I throw out a conjecture with reſpect to the uſe of ganglions different from any that have, I believe,

---

* Page 77.

been entertained. When a man examines a ſubject up and down, and ſideways, ſome new idea will generally turn up. Is it not poſſible that ganglions may be deſigned to arreſt the impreſſions which the nerves of ſenſe receive from without, and to prevent thoſe impreſſions from being communicated too ſuddenly to the brain, and too ſuddenly impreſſed upon it*? Is it not poſſible that they may harmonize and aſſimilate as it were the external impreſſions, in the ſame manner as we preſume the lymphatic glands aſſimilate the fluids which the lymphatic veſſels abſorb? Is it not poſſible that the ſpinal marrow itſelf may conſtitute the ultimate medium through which theſe impreſſions, after having been perfected, are communicated and conveyed to the brain, as the immediate ſeat in which conſciouſneſs reſides?

---

* The ſublingual nerves alone, which are diſtributed upon the tongue, and are the immediate organs in which the ſenſe of taſte reſides, are ſupplied with ganglions: ſuch however is the extent and varied appetite of this organ, that there ſcarcely exiſt any bounds to its wants: in man, it ſeems more extenſively diffuſed than in other animals in general. The nervous papillæ ariſe from the whole ſurface of the tongue; they are externally protected by the mucus only, which is ſecreted from ſeveral glands; but internally by the power which it is probable the ganglions poſſeſs of arreſting and aſſimilating the force of the impreſſion.

That the human ſpecies poſſeſſes a ſenſibility to receive impreſſions in a more exalted degree than animals in general, is not only evident from the fact itſelf, but from the tenuity of the protecting media, which the nerves receive from the rete mucoſum and cuticle. It does not however appear that the particular organs of ſenſe preſerve the ſame pre-eminence; for it cannot be queſtioned but that animals in general, and the lower order in particular, poſſeſs organs of ſenſe better conſtructed for the reception of extended impreſſions, ſo that they become more generally diffuſed upon the nerves by which thoſe impreſſions are received; and that the nerve itſelf is comparatively larger with reſpect to the ſize of the brain, where the impreſſion is depoſited, than what it is in the human ſpecies.

The human ſpecies, as I have ſaid before, is deſtined to lead a contemplative, rather than a ſenſual exiſtence. Whilſt man poſſeſſes in common with other animals organs of ſenſe, through which he receives impreſſions from without, and obtains a knowledge of external objects; it is the energy of mind in particular, in contemplation and abſtraction, by which the excellence and power of man are eſpecially diſtinguiſhed and characteriſed. The firſt knowledge he acquires is received from without through the organs of ſenſe; and without thoſe avenues, by which the mind is conſtantly ſupplied with freſh materials, it would frequently ſink into a ſtate of torpor and oblivion. The ſpark therefore comes from without, but the flame reſides within. It is ſet in motion by external means; but it is by the inherent powers of mind exerted and infinitely varied, that man is capable of acquiring a diverſity of knowledge by progreſſive means, and of diſplaying that knowledge in the works of art, by means of the various muſcles with which he is ſupplied.

It were foreign from my purpoſe to trace the nerves that are immediately deſtined to convey the energy of the will to the different voluntary muſcles by which that energy is to be diſplayed. Although the will cannot prevent the optic nerve from being impreſſed by the ſolar rays when it is expoſed to them, it is able by means of the muſcles under its controul to modify thoſe rays, ſo as either to contract or enlarge the ſphere of their operation; or to exclude them altogether, by covering the globe of the eye. The will has the ſame power, although in a leſs degree, over the auditory and olfactory ſenſes. By the power of the will, the voluntary muſcles that are diſtributed to the external ear, may be excited ſo that the vibratory motion of the air may either be conveyed and directed to the tympanum, or their influence may in ſome meaſure be avoided. By the power of the will, the noſtrils are enlarged or contracted, and volatile bodies are either ſnorted up, excluded, or expelled; and it is highly probable that, by the energy of the will, muſcles ſituated near the ſurface of the body have the power of putting the ſkin in ſuch a ſituation, that the extremity of the ſentient nerves becomes better fitted to receive impreſſions from without, when the mind is particularly intent on objects of ſenſe*.

---

* This power is particularly obvious in quadrupeds; they have

The nerves that go to voluntary muſcles are altogether deſtitute of the ganglions I have deſcribed: they have frequent communication with each other by what anatomiſts call *nervous plexus.* A nervous plexus ſeems deſtined to enlarge and extend the ſphere of ſenſation as well as the power of volition. It is by means of this communication, that when an impreſſion is produced in one part, it is communicated and felt in parts remote from it; ſo that *ſympathy* takes place in different parts, which are made to act at one and at the ſame time, by one cauſe acting upon one part alone. It is the energy of the will putting the different voluntary muſcles in action, by which the different works of art are performed.

On Muſcular Motion.

The muſcles of the human ſpecies, however weaker they may be than thoſe of very many other animals, are certainly more numerous and more complicated in their fa-

---

have a thin muſcle called panniculus carnoſus, which is ſituated on the external ſurface of the ſkin, by the action of which the hair becomes immediately erected.

bric; by means of which man poſſeſſes in a more eminent degree than any other being, the power of executing whatever the ingenuity of his mind may conceive. It is as means ſubſervient to this uſe that he is endowed with fingers of conſiderable length, tipped and terminated by nails, in order that he may poſſeſs the power of graſping objects of different degrees of magnitude, from the moſt ſolid to the moſt tenuous and ſubtle. By exerciſe theſe muſcles generally improve both in ſtrength and ability, acquiring by habit the faculty of performing different ſpecies of work with facility and expedition.

It is by exerciſe that ladies, from the delicacy of their fingers, are able to excel in the finer ſpecies of needle-work, and to give their delicate touches to muſical inſtruments. It is by exerciſe that our artiſts and manufacturers bring their various works to a ſtate of perfection, and the muſcles acquire the habit of performing the ſame actions for a conſiderable time without much additional fatigue.

If any one doubts the faculty which the muſcles poſſeſs of accommodating themſelves to the controul of the will, I would recommend him to trace the alteration which they ſuſtain, when the ruſtic is taken from the plough, and made to undergo one month's diſcipline in St. James's Park by a corporal of the guards.

It is by exerciſe that men become dexterous pugiliſts and alert pedeſtrians; and it is worthy of notice, that Sir George Staunton, in the hiſtory which he has lately publiſhed of the embaſſy to China, mentions that the Chineſe have acquired ſuch perfection in the motion of their toes, that they play at ſhuttlecock with them with as much ability as Europeans by the aſſiſtance of the battledore.

The number and extent of our toes, and the different muſcles by which they are moved, might perhaps lead one to doubt whether they are not deſtined to anſwer ſome other office than that of adding grace and ſtability to our frame. It muſt however be remarked, that in conſequence of the biped nature of man ſuch a proviſion becomes neceſſary; for although hoofed quadrupeds may be conſidered as having one toe only as the termination of each foot, the ſtability which they acquire from the four legs by which the body is ſupported, renders unneceſſary a ſurface as widely extended as our own. There are ſome muſcles that have the power of acting during the whole period of man's exiſtence, without either ſuffering any degree of apparent weakneſs, or imparting to the mind any ſenſation of uneaſineſs; ſuch as the heart and arteries, the diaphragm and other muſcles, whoſe arteries ſeem to be remote from the influence of the mind. On the contrary, the different muſcles that are immediately under the controul of the will, have their powers more limited and confined: if they are kept in a ſtate of action for a conſiderable time, or exerted beyond their power for a ſhort time, weakneſs in them directly enſues, and produces the ſenſation of fatigue, accompanied by an inability to move. It is by the energy of the brain conveyed through the medium of the nerves, and diſplayed by the different voluntary muſcles with which the ſyſtem is ſo abundantly ſupplied—it is eſpecially by the energy of the mind itſelf in the act of meditation and of abſtraction, that the ſtrength and power of the animated ſyſtem become perpetually weakened and exhauſted, and verge to diſſolution and decay.

From the exceſſive languor and debility which is produced by intenſe thought, independent of muſcular exertion, and from the want of renovation and ſupply which the ſyſtem in conſequence feels and demands, I am convinced that the blood undergoes a greater degree of deterioration by the ſpecific action of the brain in a ſhort time, than what it ſuſtains by muſcular motion long continued; and that the philoſopher in his cloſet conſumes and expends more of the vitality which his frame contains, than the mechanic who is employed in executing work of the moſt laborious kind.

In every caſe, it is owing to the various actions which theſe different organs perform, that the ſyſtem becomes ſo much weakened and exhauſted, that a ſupply of food is rendered conſtantly neceſſary, in order that the blood may be renovated from the loſs it ſuſtains: we may judge in ſome degree the deterioration which it ſuffers in quality, from the neceſſity that ſubſiſts of frequent inſpirations, by means of which, it becomes meliorated and renewed. It is this waſte which is produced in the blood of the anxious and penſive lover, muſing after the fond object of his deſire, that makes it neceſſary for him to ſob and ſigh to prevent ſuffocation. It is from the ſame loſs, occaſioned by different means, that the hunter and the pugiliſt are obliged to inſpire very frequently, in order that the blood may be preſerved in a fit and healthy ſtate.

That the exertion of this intellective and voluntary power has this debilitating effect upon the blood, by which a conſtant melioration is rendered neceſſary, is further proved from the mode of ſubſiſtence which we behold in different animals, and the different means they ſeverally poſſeſs by which this melioration may be effected.

A large portion of the lower claſs of animals, when they are employed in attaining the final cauſe of their exiſtence, feel the ſame wants, and are as indigent of food as the human ſpecies itſelf. On the contrary, after their final cauſe has been fulfilled, their voluntary powers become weakened and ſuſpended; their organs of reſpiration and of digeſtion are torpid and dormant, ſo that the animal ſubſiſts in that ſtate for a conſiderable time, deſtitute of any food whatever. And we may in general conclude, that in proportion to the magnitude of the brain, with relation to the organs of ſenſe, or nerves of ſenſation, the neceſſity exiſts for large reſpiratory organs: and on the contrary, in proportion to the magnitude of the organs of ſenſe and nerves of ſenſation to the ſmallneſs of the brain, organs of reſpiration comparatively ſmall become adequate to the end: in every caſe the organs of renovation being ſufficient to anſwer the waſte occaſioned by the organs of ſenſation and reflexion. The ſmall degree of intellectual or voluntary energy which the amphibia or fiſhes diſplay, makes it unneceſſary for their ſyſtem to poſſeſs organs of inſpiration equal to thoſe which the higher order contain. Where the deterioration of the blood is ſmall, the organs of purification need not be great. On the contrary, when the deterioration is great, the organs of purification muſt not be ſmall; otherwiſe the ſyſtem would periſh and decay in the very effort of attaining the end for which it was created.

The higher order of animals, therefore, have large lungs with *ſmall* cells; by means of which conſtruction, the area of their ſurface is conſiderably increaſed, and more widely extended, ſo that they evidently poſſeſs a greater power of acting upon a larger quantity of air. On the contrary, the amphibia have lungs with *large* cells, ſo that the area of their ſurface is conſequently greatly diminiſhed, and the quantity of air they conſume is comparatively very ſmall. It is owing to the ſmall degree of waſte which the ſyſtem of fiſh ſuſtains from the imperfect rational power it poſſeſſes, that gills (branchiæ) are adequate to the taſk of purifying their blood, by ſeparating from water, the air alone which it contains*.

When we reflect on the conſtant neceſſity that ſubſiſts for taking in air by inſpiration,

---

* It is, as I have ſaid before, owing to the ſmall degree of waſte which the fœtus in utero ſuſtains, in conſequence of being deſtitute of any intellective and perhaps voluntary energy, that reſpiration becomes unneceſſary, and that the power of the placenta is alone adequate to ſupply it with blood fit for the condition in which it ſubſiſts.

fifteen

fifteen or twenty times in one minute, for the purpoſe of preſerving the ſyſtem in a healthy ſtate; and when we conſider that the total ſuſpenſion of all vital action enſues, if this proceſs be ſuſpended for a few, very few minutes; we ſhall at once be led to conclude, that the melioration of the blood in point of quality, from the lungs, is even of more importance than the ſupply it receives in point of quantity from the ſtomach. In many caſes we have known perſons living for a conſiderable time upon the ſmalleſt poſſible quantity of food introduced into the ſtomach: the moſt notable inſtances of this kind, perhaps, that have ever happened, were experienced by Captains Inglefield and Bligh, and by their fellow ſufferers. Theſe are, however, extraordinary caſes, and which never happen without derangement or deſtruction to the ſyſtem.

Before I proceed to point out the particular means by which the blood is renovated from the loſs it ſuſtains in point of quantity, by the different functions which animals perform, I ſhall ſhew the manner how they have been claſſed and arranged, in order that our knowledge of them may be better underſtood, their complicated nature ſimplified, ſo that order and ſymmetry may ariſe out of chaos and confuſion.

CHAP. VI.

ON THE LINNÆAN CLASSIFICATION OF THE ANIMAL KINGDOM.

The whole animal kingdom divided by Linnæus into ſix claſſes.—Claſs 1. *Mammalia.* 2. *Aves, Birds.*—3. *Amphibia.*—4. *Piſces, Fiſhes.*—5. *Inſecta, Inſects.*—6. *Vermes.—Characters of each, &c. &c.*

IT were an object of the greateſt utility, if we were able to reduce the multitude of animals with which our ſyſtem abounds, into different claſſes and orders, ſo that the preſent intricacy of the ſubject might be facilitated: various attempts have been made with that view, from the time of the great ſtagyrite (Ariſtotle) to the preſent day by Mr. Pennant. It would however ſeem, that objec-

tions

objections may be made to all, and that the Linnæan ſyſtem, however defective and perhaps erroneous it may be in ſome parts, is the leaſt imperfect of the whole. In the firſt volume of his Syſtema Naturæ, after taking a philoſophical view of the ſubject in general, Linnæus proceeds to the claſſical characters from the internal ſtructure of animals. By this natural diviſion, all the animal kingdom divides itſelf into ſix claſſes as follow *:

Animals with the heart furniſhed with

Two ventricles and auricles: Blood warm and red.	Viviparous.	Mammalia.
	Oviparous.	Birds.
One ventricle and auricle:	Reſpiration voluntary.	Amphibia.
Blood cold and red.	Breathing by gills.	Fiſhes.
One ventricle without auricle: Sanies, cold and colourleſs.	Antennated.	Inſects.
	Tentaculated.	Worms.

To this account of the internal ſtructure, the author adds all the differences ariſing from the lungs or other organs of reſpiration, from the maxillæ, jaws or mandibles, organs of generation

---

* I have taken the analyſis of the Linnæan ſyſtem from Dr. Kentiſh's Oration on the Method of Studying Natural Philoſophy.

generation or ſenſation; the teguments, or outward covering, and the fulcra, or legs, wings, &c. At the head of each claſs is given a conciſe deſcription of the claſſical character, including an explanation of the terms belonging to the claſs. We have likewiſe a general enumeration of the beſt authors on each; a part of the work exceedingly uſeful to ſtudents, and from which we ſhall occaſionally borrow, in our view of the method of ſtudying this part of the creation.

CLASS I. MAMMALIA.

Comprehends all thoſe animals which we call quadrupeds, (except the lizard genus, or reptiles pedati, as they are called) and likewiſe the cetaceous order, or whales, cachalots, and porpuſſes *. Several authors have diſſented from this arrangement of whales with

---

* Objections have been made to the introduction of whales into the claſs of mammalia. It however appears to be very correct: they have lungs, a heart with four cavities, ſexual organs, and indulge in ſexual intercourſe like quadrupeds: they are viviparous, and after parturition the mother ſuckles her young by means of teats, as perfectly as an Alderney cow. Author.

quadrupeds, and the author had ſeparated them in the firſt edition of his Syſtema Naturæ; but upon reflection he thought himſelf juſtified in ſuch a claſſification. The ſtriking particulars in which they differ from fiſhes, as the ſtructure of the heart, having lungs for reſpiration, moveable eye-lids, being viviparous, and furniſhed with teats, all incline him to refer them to this claſs. The ſingle circumſtance of living in the ſame element is therefore overlooked.

The mammalia are divided into ſeven orders, which are principally taken from the difference in the number, ſituation, and form of the three kinds of teeth with which animals are endued, viz. the *primores* or *inciſores*, called the fore-teeth or cutting-teeth; the *laniarii* or *canini*, dog teeth, canine, or lacerating teeth; and the *molares*, grinders, or double teeth. Our author likewiſe takes into conſideration the feet, as will appear from the following view of the orders.

I. Digitated.

Fore teeth, four. Canine
ſingle, - - - Primates. 1.

Fore

Fore teeth, none	Bruta.	2.
Fore teeth, 6, 2, 10 conical. Canine ſingle -	Feræ.	3.
Fore teeth, two. Canine none - -	Glires.	4.

II. Hoofed.

No fore teeth above -	Pecora.	5.
Fore teeth above and below	Belluæ.	6.

III. Deſtitute of Hoofs or Claws.

Teeth, various in the different genera -	Cete.	7.

We ſhall here detail the characters as they ſtand at the head of each order.

I. Primates. Animals furniſhed with fore teeth, or cutting teeth: four above; parallel. Two pectoral teats.

II. Bruta. No fore teeth.

III. Feræ. Six ſharp fore teeth in the upper jaw. One canine tooth on each ſide.

IV. Glires. Two fore teeth in each jaw, cloſe together; but remote from the grinders. No canine teeth.

V. Pecora. No fore teeth in the upper jaw; ſix or eight in the lower jaw very remote from the grinders. Hoofed feet; inguinal teats.

VI. Bellua. Fore teeth truncated. Hoofed feet.

VII. Cete. Breathing apertures on the head. Pectoral fins. Tail placed horizontally. No claws.

Many objections have been made to this ſyſtem of claſſification. It is ſaid to be arbitrary and unnatural. Animals are claſſed together whoſe figure and habits are diſtinctly different. It is therefore alleged that the method is imperfect; and the fact may be admitted without any detraction from its real merits. For although the pride and aſſumed conſequence of man may be offended when he beholds himſelf ranked with the brute creation, and finds that even the internal ſtructure of ſuch a hideous monſter as the bat reſembles the real formation of his frame; yet on minute enquiry he will have cauſe to admire the ſimplicity and magnitude of that ſyſtem which ſhews him his real ſtation, and makes him acquainted with the wondrous extent of his own empire. Linnæus has placed man at the head of the Primates, and given him the Grecian dictate, "Know thyſelf," as his motto. By a conciſe and elegant comment he endeavours to ſhew, that however near his alliance to the mere animal, yet by the culture of his faculties it is in his power to prove himſelf an *intelligent and moral being*.

The nature of our plan will not allow us to enter into a detail of the genera or ſpecies; we ſhall therefore continue our view of the ſyſtem, by an examination of the orders of the remaining claſſes.

CLASS II. AVES. BIRDS.

Linnæus has divided theſe into ſix orders, the diſtinctions of which are chiefly taken from the beak; but it has been neceſſary in ſome genera to take in the tongue, nares, or noſtrils, and likewiſe the feet, and other parts.

I. Accipitres. Rapacious. Birds having the upper mandible of the beak furniſhed on each ſide with an angular proceſs.

II. Picæ. Pies. Birds having the beak rather compreſſed on the ſides, and convex on the upper part.

III. Anſeres. Web-footed. Theſe have a beak ſomewhat obtuſe, and covered with a thin ſkin; at the baſe underneath gibbous, and wide at the end; the *faux*, or edges of the baſe, denticulated; the feet palmated, or webbed, and formed for ſwimming.

IV. Grallæ. Waders. Theſe have the beak ſubcylindrical, and ſomewhat obtuſe; the tongue entire, and fleſhy; the thighs naked for ſome ſpace above the knees.

V. Gallinæ. Gallinaceous. Birds having the upper mandible convex, or arched, and receiving the edges of the lower noſtrils, half covered by means of a convex membrane, rather cartilaginous; the rectrices, or tail feathers, more than twelve; the feet cloven, but the toes connected by a membrane as far as the firſt joint.

VI. Paſſeres. Paſſerine. Theſe have a conical acuminated beak; the noſtrils ovated, open, and naked.

CLASS III. AMPHIBIA.

All the animals of this claſs have not the power of living either in air or water; but they have the ſingular property of ſuſpending the function of reſpiration, and can perform it in a more arbitrary manner than other animals.

This claſs is divided into four orders:

I. Reptiles pedati. Reptiles. Amphibious animals, which breathe through the mouth by lungs only; they are furniſhed with four feet.

II. Serpentes apodes. Serpents. Amphibious animals, breathing through the mouth by means of lungs only. They are deſtitute of feet, fins, and ears.

III. Meantes. Gliders. Theſe animals breathe by means of gills and lungs, and are furniſhed with arms and claws.

IV. Nantes pinnati. Breathing fiſhes. Theſe reſpire arbitrarily by means of gills and lungs. The rays of the fins are cartilaginous.

CLASS IV. PISCES. FISHES.

In the firſt edition of the Syſtema Naturæ, Linnæus followed the method of his friend Artedi, whoſe Ichthyology was publiſhed in 1738, in Holland. This method was eſtabliſhed on the ſtructure or ſituation of the tails in the cetaceous order, and on the difference in the gills, and rays of the fins in the other orders, whether cartilaginous or bony;

but (as we have already ſeen) the cetaceous order is now placed among the mammalia, and the nantes pinnati referred to the amphibia. In the two laſt editions our author forms four orders of the bony fiſhes (which reſpire by means of gills only), and theſe he has taken from the ſituation or abſence of the *ventral* fins. He compares theſe to the feet of other animals, and their ſituation is denoted with reference to the pectoral fins. The orders are,

I. Apodes. Fiſhes deſtitute of ventral fins.

II. Jugulares. Thoſe which have the ventral fins placed before the pectoral.

III. Thoracici. Fiſhes having the ventral fins placed underneath the pectoral fins.

IV. Abdominales. Theſe have the ventral fins placed behind the pectoral, on the abdomen. Some authors, as Artedi and Gronovius, have attempted to diſtinguiſh the ſpecies by the number of the rays in the fins; but the variation is too great to eſtabliſh a ſufficient character. The ſpecific characters are therefore, at preſent, taken from a variety of particulars, as the number of rays in the fins, the form of the tail, the cirrhi, or beard at the mouth, the length of the jaw, and the ſpots and lines on the body, &c.

CLASS V. INSECTA. INSECTS.

A great number of authors appeared before Linnæus on this ſubject; but he was confeſſedly the firſt who determined the genera of inſects, and aſſigned them their proper characters. He has arranged them under ſeven orders:

I. Coleoptera. Inſects having the wings covered with two cruſtaceous caſes, divided by a longitudinal ſuture.

II. Hemiptera. Half-winged inſects, which have the ſhells or caſes ſemi-cruſtaceous, not divided by a ſtraight ſuture, but incumbent on each other in the margin. The beak is curved inwards.

III. Lepidoptera. Theſe have four wings imbricated, or clothed with fine ſcales or feathers; tongue ſpiral, and coiled up; body hairy.

IV. Neuroptera. Inſects with four naked tranſparent, or reticulated wings; the tail in moſt kinds without a ſting.

V. Hymenoptera. Theſe have four membranaceous wings, except ſome few ſpecies, which are deſtitute of wings. The females have the tail armed with a ſting.

VI. Diptera. Inſects with two wings, having alſo a balance or club behind each wing.

VII. Aptera. Inſects without wings in either ſex.

In ſtudying this, as in every other part of zoology, it is neceſſary to acquire a certain number of terms, without which no real proficiency can be made in the ſcience. The genera of this claſs are characteriſed from certain parts of the animals, ſome of which have technical names, as the antennæ or feelers; elytra, or outward caſes; roſtra, or mouth, &c. The head, thorax, tail, and other parts, are likewiſe occaſionally uſed to aſſiſt in forming the character. The ſpecies of each of the orders are very numerous.

CLASS VI. VERMES.

We are now arrived at the laſt claſs in the ſyſtem of nature, which we are to conſider as divided by our author into five orders. Linnæus has followed the method of Peyſonel, Juſſieu, and others, by introducing the coral and corallines into the animal kingdom, under the names of lithŏphyta and zoophyta. We ſhall likewiſe find the ſtudy of a very ſplendid part of natural hiſtory preſenting itſelf to our view, in the examination of the orders of this claſs. Conchology, or the ſtudy of ſhells, has long attracted the attention of naturaliſts; and diſputes have ariſen reſpecting the proper method of ſtudying the ſubject. The ſhells themſelves, as mere coverings, or parts of living animals, cannot certainly demand our primary attention in a ſyſtem of zoology. The animals as one whole fall under our conſideration, and accordingly Linnæus has made conchology a branch of zoology, and not of mineralogy.

The characters of the orders of this claſs are very various.

I. Inteſtina. Animals ſimple, naked, deſtitute of limbs.

II. Molluſca. Animals ſimple, naked, not included in a ſhell, but furniſhed with limbs.

III. Teſtacea. Theſe are generally of the foregoing order, but included in a ſhell.

This order comprehends the whole tribe of ſhells, conſiſting of thirty-ſix genera, and above eight hundred ſpecies, diſpoſed according to a new method. The three firſt genera are called multivalves; the next fourteen bivalves; and the remainder univalves.

IV. Lythophyta. Theſe animals are compoſite. They are affixed to, and fabricate a fixed calcareous baſe, known by the name of coral.

V. Zoophyta. Theſe are likewiſe called compoſite animals, and ſaid to reſemble a flower, and to ſpring from a vegetating ſtem.

Obſervations are yet wanting to aſcertain the two laſt orders with preciſion. It is confeſſedly a matter of the greateſt difficulty to draw the line of ſeparation between the three kingdoms. The gradations of organized bodies are ſuch as obſtruct preciſe definition. Animals may exiſt whoſe principle of life reſides in a ſtructure of parts reſembling the organization of vegetables, as is ſaid to happen in the order Zoophyta; and it is not impoſſible to conceive that the real living parts of an animal may preſent themſelves to our view in a form reſembling that of a vegetable; but it is hardly poſſible to imagine, nay, it is diſſonant to reaſon, to affirm, that the principle of life can exiſt in unorganized matter.

The polype is evidently an animal bearing no reſemblance to a plant; and probably future attention and experience to this order may inform us, that all the animals hitherto known under the name of zoophytes, are properly referable to ſome other claſs or order. The whole order conſiſts, according to Linnæus, of fourteen genera, of which nine are fixed, and the reſt locomotive; amongſt the former are reckoned the iſis, or red coral, ſea fan, alcyonium, ſponge, corallines, &c. Among the latter the polype, ſea pens, tænia, furia, and the microſcopical animalcula. This view of the genera will be ſufficient to ſhew the great defect of the order itſelf. For the greater part of the microſcopical animalcula, or animalcules des infuſions, as they are called, have been ſhewn by the Abbé Spallanzani, and others, to be diſtinct animals, not always of the claſs of vermes. Some, indeed, have a very ſingular appearance; but I believe none of them are zoophytes. In the ſame manner objections may be made to the order of lithophyta.

Theſe animals have been ſuppoſed to connect the animal and mineral kingdoms; and it muſt be confeſſed, that they appear the laſt link in the chain of organized matter: but it appears to me, that naturaliſts have taken a ſuperficial view of the matter of fact, and deſcribed as lithophytes, ſubſtances which are in reality nothing more than the neſts of real animals.

The genera of this order are four: the tubiporæ, or red tubular coral; madrepores, or brain ſtones; millepores, and cellepores. In each of theſe kinds we obſerve certain pores or cells, apparently the receptacles or habitations of diſtinct animals. The aſſemblage which we view is not therefore to be conſidered as an animal, but rather as the fabrication of many animals, in the ſame manner as a ſhell is the work of a ſingle animal. The coral, in my opinion, properly ſpeaking, is no more a lithophyte than any of the ſpecies in the order teſtacea. It muſt, however, be confeſſed, that this ſubject is at preſent involved in great obſcurity.

But to return: the generical diſtinctions of the claſs of vermes are taken from a variety of particulars which deſerve our attention. In the inteſtina the genera are characterized almoſt ſolely from the diverſity of the body of the animal. In the molluſca, from the body and feelers, called tentacula, and from other parts.

In the teſtacea, the included animal, the general differences among the ſhells themſelves, and principally the *cardo*, or hinge in the bivalves, together with the *aperture* in the univalves, furniſh the general character.

In the lithophyta the inhabitant animal is conſidered with the form of the coral itſelf: a proof of Linnæus's opinion of the real nature of theſe animals. He conſiders the whole as the fabrications of different animals, and not as one whole animal itſelf. Have ſubſequent naturaliſts entertained the ſame ideas?

In the zoophtya again the animal and the different forms of its fabrications lay a foundation for the generic notes.

CHAP. VII.

ON THE DIFFERENT SPECIES OF ALIMENT THAT ARE EMPLOYED BY DIFFERENT ANIMATED SYSTEMS.

The aſſimilating organs of different ſyſtems examined—of herbivorous and carnivorous animals in general, with relation to their food, and that of the human ſpecies in particular—the food moſt congenial to man pointed out, &c. &c.

BY taking a general review of the different modes of ſubſiſtence in different orders of animated beings, we ſhall find that they are naturally led to ſelect particular ſpecies of food as means of ſupport, and that it is for the moſt part obtained either from the animal or vegetable kingdom; water alone ſeeming to conſtitute the principal exception. It is from this natural propenſity which animals poſſeſs, that claſſifications have been ſometimes made of animals into herbivorous and graminivorous, into carnivorous and omnivorous. It would however appear that there is a great and ſtriking difference in the degree of aptitude to be digeſted ed, which the different articles of food ſeverally poſſeſs; ſo that a neceſſity ſeems to exiſt that an additional proviſion ſhould be formed, by means of which, the food that poſſeſſes the leaſt aptitude to be aſſimilated, ſhould be deſtined for the nouriſhment of the ſyſtems, where the aſſimilating organs are moſt extenſive. It would therefore appear to be with a view to this end, that the aſſimilating organs of herbivorous animals in general are found more complicated in their ſtructure, than thoſe of carnivorous in particular.

Of the Aſſimilating Organs of Herbivorous Animals, as the Cow, &c.

The food which herbivorous animals receive, after having been torn by the action of the inciſores teeth, paſſes through the œſophagus into a large bag, or paunch, which appears by the mode of its ſtructure to be very differently organized. The half which firſt receives the food is covered over by a thick cuticle; the other half is deſtitute of this covering, but is lined over by a mucous membrane, which ſecretes a large quantity of mucous matter. After the nutriment has been ſome time in this organ, a ball of food aſcends out

of

of it and returns back into the mouth, where it undergoes a further proceſs of maſtication (chewing the cud, as it is called): it then paſſes through the medium of the œſophagus, by the power of which it is forced into the ſecond or reticulated ſtomach, in fabric reſembling a honeycomb. After the food has been there ſome time, it paſſes into the third ſtomach. This is internally of a laminated ſtructure, like the valvulæ conniventes of the human ſpecies, or the inner ſide of a muſhroom. The moiſture which the food contained is ſqueezed out by the power of this organ; it is there formed into a bolus, from whence it proceeds towards the left ſide, into the fourth and laſt ſtomach. The fourth ſtomach is of a membranous ſtructure, having within a number of longitudinal rugæ. It is not until the food has reached this organ that it becomes prepared to undergo the final proceſs of aſſimilation. The alterations it undergoes by the action of the three firſt organs, are merely to prepare and fit it for the action of the laſt, which ſeems deſigned to perform the ſame purpoſe of aſſimilation as that of the human ſpecies*.

---

* Cows and horſes eat hemlock; hares eat milk thiſtles; hogs fatten on henbane; quails on hellebore; and goats on

If we examine the digeſtive organs of *granivorous birds*, we ſhall find them equally complicated in their ſtructure. After the food has been taken up by the bill, which is generally blunted and hollow, it is conveyed by the aſſiſtance of the tongue into the œſophagus, which is of conſiderable magnitude. The œſophagus, after paſſing under the breaſt bone, opens into the crop. The crop is of a glandular nature, ſecreting a fluid which is eſpecially deſtined to act upon the food, and aſſimilate it to the nature of the ſyſtem itſelf *.

There is a canal that proceeds from the crop, and which may be conſidered perhaps as a continuation of the œſophagus, that terminates in the gizzard.

---

on euphorbium. A horſe can take more glaſs of antimony than would kill an hundred men; a dog, more opium than would kill an unaccuſtomed man; while an ordinary doſe of jalap, of nux vomica, or a few bitter almonds, would convulſe or kill him. Bitter almonds kill different kinds of birds likewiſe; and parſley is poiſon to parrots. Indeed every animal and vegetable poiſon is the food of ſome animal. Vide the late Dr. Webſter's tracts, &c.

* There are ſome birds, as pigeons, that ſecrete a milky fluid for the purpoſe of nouriſhing their young, and which is known by the name of pigeon's milk.

The gizzard is muſcular and tendinous in its ſtructure: it is lined by a thick cuticle, and there is generally found within the internal ſurface (which is comparatively ſmall to the ſize of the organ itſelf) a number of ſmall ſtones which the animal picks up, and which ſeem to perform the office of teeth: they are commonly larger than the grain on which it feeds. The ſtrong muſcular fabric of which the gizzard is compoſed, performs the ſame office as the maſſeter and pterygoid muſcles. By preſſing upon theſe ſtones, and the ſtones upon the food, a proceſs of trituration is effected; the food is broken down, and more eaſily acted upon by the gaſtric juice with which it is involved. It does not however appear that the digeſtive proceſs has even then taken place. The food is propelled from the gizzard into the true digeſtive ſtomach, and from thence into the inteſtinal canal. The inteſtinal canal has a number of inteſtina cæca, which appear to poſſeſs a digeſtive power alſo; for, if the food be examined which is in them, it ſeems to be much further advanced in the proceſs of aſſimilation than that which is in the inteſtines. Nor do the aſſimilating organs alone ſeem more complicated in herbivorous and graminivorous animals than in carnivorous, but the inteſtinal canal alſo: it is in them infinitely larger, and better calculated to receive an additional quantity of fæculent matter, and to accommodate itſelf to the decompoſition which it ſuſtains, than that of carnivorous animals.

On the contrary, if we examine the digeſtive organs of carnivorous animals, we ſhall find that they are more ſimple, becauſe the aſſimilation of animal food is ſooner effected, and does not ſeem to require a proceſs ſo elaborate as that which we have deſcribed.

In *birds of a carnivorous kind*, like the eagle, hawk, cormorant, crow, raven, &c. the œſophagus in them does not terminate in a crop, but in a membranous ſtomach, ſomewhat ſimilar to the human; and the inteſtinal canal, inſtead of being proportionably long, is relatively ſhort.

The ſtomach of *carnivorous quadrupeds*, although more capacious, is marked with the ſame ſimplicity in its fabric: it is of the ſame nature as the human ſtomach; although it is probable that the aſſimilating powers it contains are far ſuperior to our own. The neceſſity of this will be apparent, if we reflect on the crude and living ſubſtances which theſe animals prey and feed upon, and the amazing powers theſe organs muſt conſequently poſſeſs, not only to be capable of deſtroying the living and active powers of thoſe ſubſtances, but to aſſimilate them afterwards to the nature of the ſyſtem.

There are many well authenticated facts which prove that various ſerpents ſwallow whole animals of prodigious magnitude, and where the proceſs of aſſimilation completely takes place. Pigs and deer are frequently devoured by them; and it has been mentioned that the large Boa ſnake and the copra de capello have been known to devour a young buffalo.

Snakes ſwallow in one morſel the food on which they feed; it paſſes through the œſophagus, which appears to be a mere partition from the mouth into the ſtomach, which is very large, and ſuſceptible of prodigious diſtenſion.

The aſſimilating power of the lower order of animals is ſtrongly marked by the facility they poſſeſs of converting to their own nature ſubſtances of the moſt ſimple kind, in a manner ſufficiently perfect to anſwer the purpoſe of evolution and of reſtoration.

It is unneceſſary for me again to relate the experiments which Dr. Fordyce made upon fiſh,—animals of a carnivorous nature.

Although they were deprived of animal food altogether, the aſſimilating powers of their ſtomach were ſufficiently ſtrong to convert the water and air on which they fed, into chyle; and which anſwered every purpoſe for which it was deſigned. The mouth of fiſh, which is generally very large, terminates in the œſophagus; the œſophagus itſelf is extremely ſhort, and opens into the ſtomach, an organ which in them is of very conſiderable magnitude. On examining the ſtomach of different fiſhes, it is very common to find within it a quantity of milky fluid, exactly reſembling chyle, and which ſeems to ſhow that the chylopoeſis takes place more completely in this order of beings than it does in thoſe of a higher claſs. They generally ſwallow their food whole, and it is conveyed into the ſtomach without previous maſtication. It is curious to obſerve in fiſh the magnitude of the ſtomach and the ſmall ſize of the inteſtines, there being three convolutions only. In the *cartilaginous* fiſh there is an appendix cæci, which ſeems evidently to act upon the aliment which the ſtomach had not completely aſſimilated, and to finiſh what the ſtomach had begun; it is of a very follicular ſtructure, and ſituated about two inches from the anus.

In the *bony* fiſh the ſtomach ſeems to poſſeſs the ſame relative magnitude; and the ſame proviſion for the final aſſimilation of the food exiſts in the inteſtinal canal, although the conſtruction is ſomewhat different: inſtead of an appendix cæci, there are a number of ſmall inteſtina cæca attached to the ſmall inteſtines, and where the food undergoes a more perfect and complete change.

Of the Nature of the Food deſtined for the Uſe of Man.

Such is the total indigency of the human ſpecies, and of the higher order of animated beings, that, if it were not for the protecting and foſtering care of their parents, their exiſtence would no ſooner begin, than, like the ephemeris of a day, it would inſtantly terminate. The offspring of vegetables are ſeparated from the parent ſtock by the rude blaſts to which they are expoſed, and ſubſiſt totally independent of them. The ſame ſtate of independence exiſts in fiſh, and the whole of the inſect tribe. This ſtate progreſſively decreaſes as we proceed from birds to the higher order of animals.

The lower order of theſe poſſeſs, for the moſt part as ſoon as born, the powers of locomotion, and therefore are capable of going in ſearch of food; but the higher orders are totally helpleſs of themſelves, and wholly dependent on the mother for nouriſhment and ſupport.

Different therefore are the ends which the Deity has in view in the generation of man and the other orders of animated beings. Thoſe that have not the power of providing for themſelves, are protected and provided for by the parents; ſo that, in the moſt rational ſyſtem, the mother not only affords nouriſhment to her offspring before, but after it is born. The organs that are allotted this office are ſituated in the thorax upon the pectoral muſcles: ſoon after parturition is accompliſhed, the mammæ receive an increaſed ſupply of blood, which they ſeparate and convert into milk: the glands, which are eſpecially allotted this office, have their actions excited and continued by the irritation which the nipples receive, and which the lips and tongue of the infant are deſtined to impart.

Such is the ſenſe of want which the infant feels as ſoon as it is born, that it is inſtinctively led to move its lips, in ſearch of the nouriſhment ſo congenial to the nature of its frame. It is unneceſſary to give a chemical analyſis of the properties of *milk*: it is ſufficient for me to ſay, that it is of a bland and agreeable taſte, of a white colour, and, when in its pure and healthy condition, deſtitute of any acid or alkaline properties: it ſeems in fact principally compoſed of the ſerum and coagulable lymph of the blood, abſtracted of the red globules. It is this food which appears eſpecially fitted for the ſupport of the infant ſyſtem, and that poſſeſſes the ſtrongeſt aptitude to be acted upon by the infant ſtomach, and aſſimilated to the nature of the infant frame.

When we reflect on the ſtructure of the gums in the infant ſtate, no doubt can exiſt but that aliment of a fluid kind is beſt fitted for the ſubſiſtence of the infant. There are various ſources from whence aliment of a ſimilar nature may be obtained; it is produced by the breaſts of all the females of the mammalia claſs after parturition. When there is a deficiency of the mother's milk, that of cows, of goats, and of aſſes is frequently ſubſtituted in its ſtead *.

It

---

* There are very few parents who have not cauſe to deplore the pains and concomitant danger that attends the teething of their children. I cannot avoid, in this place, moſt ſtrongly urging the more frequent practice of lancing and dividing the gums, when ſymptoms ariſe that ſeem to proceed from the ſhooting of the teeth. I ſpeak from the very frequent good effects I have ſeen it produce. I ſhall however relate the caſe of one of my own children, as in none have I ſeen the effect more ſtriking. He was a boy ſeven months old, of a healthy conſtitution; he was ſeized with fever, accompanied with conſiderable pain: although he uſed to put his fingers to his mouth, there neither was any appearance of teeth, nor were his gums any way ſwelled. The fever increaſed: on the ſecond and third day, ſymptoms of inflammation of the lungs came on, with exceſſive reſtleſſneſs manifeſted by conſtant lamentations and cries. I bled him with leeches, put him repeatedly in the warm bath, gave him frequent doſes of antimonial medicine to produce perſpiration, with diluting drink, and applied a bliſter to his cheſt. All my endeavours ſeemed of no avail; the fever and peripneumonic ſymptoms increaſed; and I am ſure that for three days together he was but a few hours without crying, although I tried to compoſe him by means of an opiate.

The caſe became ſo urgent, that although the gums did not appear ſwelled, I determined in the middle of the fifth night to try what effect the lancing of them would produce. I divided the gums that cover the two upper and

lower

It therefore unqueſtionably appears, that the human ſpecies, from the moment of its creation, is naturally deſtined to ſubſiſt on animal food: it might conſequently become a queſtion, whether we do not deviate from the path which nature has pointed out, when we allow infants to feed upon ſubſtances that are produced not by the animal but by the vegetable kingdom; and whether it were not better to liquefy animal matter in the form of broth, as a ſubſtitute for milk, than have recourſe to the various farinaceous ſubſtances that are in common uſe.

Upon a ſubject ſo univerſal as this, a great variety in opinion will naturally exiſt; and it is certain, that in very many inſtances farinaceous food will prove highly nutritious.

lower inciſores very widely, puſhing my lancet down until I felt it reſiſted by ſome ſolid ſubſtance. In five minutes, the child that had ſcarcely ceaſed crying for ſeveral days, became tranquil; he fell into a moſt profound ſleep, a fine perſpiration came on, the fever and peripneumonic ſymptoms went off, and in two days he was perfectly recovered, weakneſs alone excepted. As I never ſaw a more ſtriking effect produced, I hope I ſhall be pardoned for having dwelt upon it; but when caſes like this ſo very commonly occur, the plan cannot be too generally recommended.

I am convinced that it has a much ſtronger tendency to undergo a ſtate of decompoſition and aſſume its chemical changes, by reſiſting the powers of aſſimilation, than food of an animal nature; and that to weakly children animal food is preferable to vegetable.

When we reflect on the various ſituations which man chooſes for his habitation, no doubt can exiſt but that this circumſtance alone will cauſe a great variety in the effect produced by the aliment of every kind which he receives. In the country, where the air is pure, and the blood has abundant ſources of melioration from the lungs, the ſtomach not only poſſeſſes greater power of converting the ſubſtances it receives, but the neceſſity does not exiſt that thoſe ſubſtances ſhould contain ſo ſtrong an aptitude to be acted upon as in town, where the impure air deprives the blood of the ſame ſource of amendment. It is on that account, that in the country, where the air is pure, children thrive upon food which would ſtarve them in large cities; and however true it may be, that water may be nutritious to the one, I am convinced that wine and fermented liquors are very proper for the other. I am ſatisfied, from the obſervation I have been able to make, that it is an erroneous plan to feed children on vegetable food, and debar them from the habit of eating animal;—to make them take water for their drink, and prevent the moderate and temperate uſe of beer or wine. If I were aſked what are the deleterious effects produced by the vegetable plan; I ſhould ſay, that it is the cauſe of chilblains, of rickets, of the imperfect formation of bones, followed by a mal-conformation of the cheſt, prediſpoſing the ſyſtem to phthiſis; of mal-conformation of the pelvis, the effects of which are more eſpecially felt by the female ſyſtem; that it is the cauſe, in both ſexes, of glandular and ſcrophulous ſwellings, &c. &c. &c. *

We

---

* It fell to my lot lately to go to Old Hampton, a low uncultivated ſpot on the Eſſex ſhore, inhabited by two families alone. Two women and four children that were there had the ague habitually and conſtantly upon them; and on enquiry, I found that they lived with the utmoſt penury, and principally on vegetable food. The men uſed to have the ague occaſionally alſo; but whenever they

We can form but very imperfect notions of the power which the human ſtomach poſſeſſed in the early ages of the world, when mankind exiſted in a ſtate of purity and virtue, from what it does at this time, when the human frame has been gradually weakened by the hereditary vices of ſucceeding generations *. There is another ſource of debility of a more conſiderable kind: I mean the various mental occupations which naturally proceed from men in ſociety, and the congregation of mankind in collected habitations or towns, &c. There can be no doubt but that theſe cauſes contribute in an eſpecial manner to weaken the powers of the human frame, and to impair the functions of the aſſimilating organs. In ſavage life, where

---

they could procure gin, or other ſpirituous liquors, it put off the paroxyſm for ſeveral days. Such was the prejudice againſt the bark, that the very mention of it I thought would produce a ſhivering fit.

* In the earlieſt ages of the world, before the deluge, it appears that man was deſtined eſpecially to live on vegetable food. In the firſt chapter of Geneſis, ver. 29, God ſaid to Adam, "I have given you every herb bearing ſeed which is upon the face of all the earth, and every tree, on which is the fruit of a tree yielding ſeed; to you it ſhall be for meat."

there is a population without ſociety, and animal powers without mental exertion, the ſtomach ſeems to be equal in power with that of the different animals I have mentioned. It is the common practice for the inhabitants that border on the Orange river in Africa, to collect round the carcaſe of a whale that may have been driven on ſhore, and to remain near it until the whole has been devoured, without any culinary proceſs whatever. We have alſo the authority of Mr. Bruce for ſtating that it is the practice of the Abyſſinians (a barbarous and ſavage race) to live upon animal food, crude and unprepared *. It does not however appear,

---

* In Abyſſinia (if we may credit Mr. Bruce) the amuſements of the gentry, during the rainy ſeaſon, conſiſt in convivial meetings of both ſexes, who are no ſooner aſſembled and ſeated round the dining-table, than a large ox or cow is brought in alive, and faſtened to the wall; whilſt a number of ſervants immediately fall to cutting up its moſt fleſhy and tender parts, and diſtributing the ſlices to the company. Every gentleman being ſeated between two ladies, is immediately fed by the obliging females, who wrap up a mouthful of meat firſt in pepper and then in taaf bread, and cram it down his throat till his appetite is fully ſatisfied; after which the gentlemen feed the ladies in return; the while the poor bleeding animal

pear, that food of this deſcription is either ſo grateful to the appetite, or equally eaſy of aſſimilation, as that which has undergone a culinary proceſs. It ſeems neceſſary that food, whether it be of an animal or of a vegetable kind, ſhould have the living power by which it is marked and characterized, and which conſtitutes the bond of its different parts, weakened and abated, in order that it may be more eaſily acted upon, and converted by the aſſimilating organs of the ſyſtem which it is deſtined to nouriſh.

It is probably with a view to this end, that the whole of the culinary art has been originally eſtabliſhed. Thus it is by a culinary proceſs, that farinaceous matter, which can preſerve its living properties for years, ſoon after it has been formed into a paſte and baked or boiled, ferments in a few days. It is by the ſame means that the bond of eſculent vegetables is weakened, and made fitter to be acted upon by the ſtomach; that ripe vegetables are more nutritious than unripe; and, finally,

---

mal bellows in vain to the ſervants, who prolong his life to keep his fleſh tender the while their maſters feed; after which they ſhare the carrion among themſelves.

thoſe

thoſe whoſe vegetative powers are totally exhauſted than when they continue, as dried figs, grapes, dates, &c. &c.

It is that great claſs of vegetables called *gramina*, which may be conſidered in an eſpecial manner as poſſeſſing properties of a nutritious nature; it is by them that the various farinaceous ſubſtances we uſe are particularly produced. It is generally ſuppoſed, that rice for its bulk contains more nutritious matter than wheat, or any other of the ſame claſs. This farinaceous matter exiſts, although perhaps in an inferior degree, in the ſeeds of moſt plants; in barley, rye, melons, cucumbers, nuts, apricots, peaches, &c.; and it has been found that the ſtems of the palmæ contain a farinaceous matter, which is highly nutritious, called by us *ſago*. Farinaceous matter alſo abounds in the root of the potatoe, in the root of the bunium, bulbo-caſtaneum, yams, &c. &c.

The ſaccharine matter alſo which fruit contains is found both grateful to the taſte and nutritious to the ſyſtem. Hence it is that the Grecians live principally upon figs; in ſome parts of Africa upon dates; and grapes conſtitute a conſiderable proportion of the diet of the poor inhabitants of Portugal and Spain *.

It is not theſe ſubſtances alone that are nutritious. Vegetable juices, and under certain circumſtances it is probable the whole of many vegetables, poſſeſs the aptitude to be digeſted, and conſequently to afford nouriſhment to the ſyſtem. It is however too digreſſive for me to examine them.

However inferior in point of nouriſhment vegetable food may be to animal, no doubt can exiſt but that it is equal to the taſk of ſupporting the human frame. The whole tribe of Gentoos live entirely upon it; although it is very certain that they are weaker than thoſe who live upon animal matter alſo. That this is a fact, is proved from hence, that the *ſoldier caſt*, which are allowed to eat animal food, are far more robuſt, and capable of undergoing greater bodily fatigue, than thoſe who live on vegetables alone; and I am credibly informed, that their muſcles are not only ſtronger, but that their bones are more ſolid, and contain a much larger quantity of earthy matter.

---

* The officer who took poſſeſſion of the St. Salvador del Mundo, in the late brilliant action off Cape St. Vincent's, aſſured me that there were only eight barrels of beef and pork on board, and which were deſtined for the uſe of the ſick; but that the crew in general, amounting to 1100 men, always fed upon boiled beans mixed with a certain proportion of oil of olives, and occaſionally a ſmall allowance of fiſh.

Seeing then that each kind of food ſeparately is adequate to the taſk of nouriſhing the human frame, we may from thence preſume, that after the organs are ſufficiently evolved, a mixture of both forms the beſt ſpecies of diet that can be adopted. Regard, however, muſt be had to the particular period of life. In infancy, before the organs are evolved, and have attained their acme of perfection, animal food is preferable to vegetable. During the period of youth and manhood, whilſt the whole of the ſyſtem is in the fulneſs of its health and ſtrength, a mixture of both becomes moſt congenial and ſalutary. But as the period of old age advances, not only green vegetables ought to be avoided and condemned, but even thoſe that are perfectly mature ſhould be ſparingly adminiſtered. It is animal food that is ſuſceptible of eaſy maſtication, or that has been liquefied into broth, that ought to conſtitute the diet of the convaleſcent or the decrepid;—for thoſe who are in the decline of life, and whoſe ſyſtem is verging to decay. A period does arrive in the latter ſtage of the natural life of man, when the organs of maſtication cannot comminute ſolid food; when the organs of deglutition can ſcarcely ſwallow it, and when the aſſimilating organs cannot convert it: ſo that liquid food alone, and that which poſſeſſes the ſtrongeſt poſſible aptitude to be acted upon, ought to be employed. It is then that the cordial effects of wine are felt, and more eſpecially thoſe of brandy, &c.: and if the ſtomach have not the power, at the laſt period of old age, of acting upon and aſſimilating the aptitude which brandy poſſeſſes, the caſe may be conſidered as deſperate indeed. The aſſimilating powers of the ſtomach are then ſo weakened and exhauſted, that the total ceſſation of organic action very ſoon enſues, and the diſſolution of the whole is the ultimate change that is produced.

It is probably owing to the total loſs of original living properties, that the fluid which is given out from vegetables by the firſt proceſs of fermentation poſſeſſes ſo ſtrong an aptitude to be acted upon, and aſſimilated by the ſtomach to the nature of the ſyſtem. Where the vegetative power in the food is weak, its aptitude to be digeſted is proportionably ſtrong; where it is deſtitute of all original living character, the living power of the ſtomach can more readily convert it. By this proceſs of fermentation we have wine and brandy produced from grapes, rum from ſugar, and ſpirit from malt.

It is from the privation of all ſenſible quality, that water poſſeſſes alſo the aptitude in ſo ſtrong a degree to be aſſimilated. Deſtitute, however, as it is (as far as we are able to judge) of any nature common with the animated ſyſtem; it would appear from thence to be unequal to the taſk of affording it a ſufficiency of ſupport when given alone, although it becomes the beſt medium in which animal or vegetable matter can poſſibly be conveyed.

It is the vehicle in which a variety of herbs are infuſed, and which conſtitute a major part of our aliment, more eſpecially tea. However grateful and ſalutary it may prove to thoſe who enjoy a plenitude of health, and who have an appetite for ſolid food, and a ſtomach ſufficiently ſtrong to aſſimilate it; I am notwithſtanding convinced, that in weak habits, and more eſpecially in thoſe who are afflicted with weak diſeaſes, tea, and eſpecially green, is extremely pernicious, being inſtrumental in debilitating and relaxing the habit, in increaſing the irritability of the nerves, weakening the energy of the mind, prediſpoſing it to hypochondriaſis, and the ſtomach to dyſpepſia. I am convinced that it is a very general cauſe of nervous and dyſpeptic complaints amongſt the ladies, and amongſt thoſe that are expoſed to fatigues either of mind or body, more eſpecially whilſt they are nurſes.

During the time of good Queen Beſs, a ſurloin of beef and a cupful of nut-brown ale uſed to conſtitute the breakfaſt of all, from majeſty itſelf down to the lower claſs: at preſent, tea is the common article of diet.

It was from a perſuaſion of the deleterious effects it produced, that the late Jonas Hanway, a man whoſe memory for patriotiſm and benevolence will be long remembered, wrote a Diſſertation againſt its uſe, exclaiming indignantly of his countrymen,

Is this the breed, were ſuch as theſe,
That quell'd the proud Heſperides?

It is impoſſible for me to go any farther in the article of diet without ſwelling this volume beyond the limits which I deſign. I have gone over it in a curſory way, merely with a view of connecting the different parts of the ſubject I am now endeavouring to explain.

Although the manner in which the body ought to be clothed is not immediately connected with the ſubject, I think it proper to ſtate, that in this country a very erroneous opinion prevails, which in its application to practice is extremely detrimental. It is generally thought that thin clothing has a tendency to harden the ſyſtem and make it robuſt; and on the contrary, that warm clothing relaxes the habit, and makes it more ſuſceptible to be affected by the viciſſitudes of the weather. From every obſervation I have been able to make, I am convinced that the infant ſyſtem is chilled and clipped in its growth by expoſure to cold; if not ſufficiently clothed ſo as to be protected from its influence, or from the ſudden changes which the weather undergoes. Thin clothing is the cauſe why ladies are ſo readily acted upon by the cold, ſo frequently attacked with catarrhs, and that phthiſis pulmonalis is more uſual in this, perhaps, than in any other country. It is by warm clothing alone, not partially but generally applied, by flannel waiſtcoats and drawers, &c. that the ſudden change of temperature can be reſiſted, and the ſyſtem itſelf protected from its deleterious effects.

CHAP. VIII.

OF MANDUCATION AND DEGLUTITION—OF THE TEETH, AS THE AGENTS BY WHICH THE SENSIBLE PROPERTIES OF SOLID FOODS ARE DESTROYED, WITH RESPECT TO BULK OR QUANTITY.

The food comminuted by maſtication, acted upon by the ſaliva, and reduced into a pultaceous maſs—propelled through the œſophagus into the ſtomach, or organ of aſſimilation, &c. &c.

IT is by the ſenſe of want which every animal feels, that it is inſtinctively led to employ the organs with which it is endowed, as means by which thoſe wants can be relieved. By the eye we behold objects, by the olfactory ſenſe we have cognizance of their flavour, by that of taſte we decide whether they be congenial to the nature of our frame. The ſenſations which the organs feel are propagated to the brain, in which conſciouſneſs is produced. It is by the energy of the brain that the voluntary muſcles are made to act, and food of different kinds is received and conveyed into the mouth. It is therefore neceſſary, to point out the different means by which food is fitted and prepared for the action of the digeſtive organs. Solid food is comminuted by maſtication, and its temperature accommodated by deglutition. Theſe proceſſes, however, are only preparatory to the proceſs of aſſimilation which it is finally to undergo.

The power by which maſtication is effected, principally depends on the action of the voluntary muſcles by which the lower jaw is moved, and the conſequent impreſſion that is produced on the food by the motion of the teeth.

It is with a view of accommodating the ſenſible qualities which food contains to the ſtate of growth which the ſtomach has ſuſtained, that we find a difference in the evolution which the organs of maſtication undergo. In the firſt months of infancy the organs of maſtication are deſtitute of teeth, and conſequently unable to maſticate food of a very ſolid kind, and the organs of deglutition ſeem eſpecially calculated to convey food either of a fluid or of a pultaceous conſiſtence.

In proportion as the evolution of the ſtomach becomes developed, and its powers increaſe, the capacity to maſticate ſolid food progreſſively takes place, and the evolution of the teeth conſequently enſues.

It is by contemplating the relation that ſubſiſts between the means and the end, between the inſtrumental and the final cauſe, that we are capable of conceiving and of beholding the beautiful harmony that ſubſiſts between all the parts of the ſyſtem, with a view to the perfection of the whole.

The firſt ſet of teeth are not only very delicate in their ſtructure, but limited in their duration; they periſh and decay, and a ſecond more ſolid and more durable than the former ſucceeds. In the decline of life, when the ſyſtem is verging to decay, the teeth ſympathize with the organs in general: they decay and fall.

Of the Teeth.

In proportion as the evolution of the ſyſtem advances, and as it becomes capable of ſupporting the effect of mental energy, and of performing voluntary action in a greater degree, a neceſſity ſeems evidently to exiſt, that it ſhould be capable of acting upon food of a more ſolid nature. It is with a view to this end, that a proviſion is made by the exiſtence of teeth. In the fœtus they ſubſiſt in an embryo condition only, and for the firſt ſix or eight months of the infant ſtate, during the time that it ſeems deſtined to live by ſuction, they are inbedded in the alveoli of the jaws, without having pierced the gums, or the covering by which they are enveloped. After this period their evolution ſeems evidently to advance, and a conſiderable interval enſues before the whole ſet has made its appearance*. The teeth have been divided into three ſpecies. The four front teeth in each jaw are called the inciſores, or cutting teeth: on each ſide of theſe there is one tooth, which, from its reſemblance to a dog's, is called the canine or dog tooth; and finally, on each ſide of theſe there are four grinding teeth, or dentes molares. The inciſores firſt make their appearance; at two years of age, the two molares, or canine teeth, generally evolve, in all twenty in number, viz. eight inciſores, eight molares, and four canine.

---

* In the intemperate and diſeaſed, and eſpecially the diſeaſed from intemperance, the teeth ſeem to ſympathize in an eſpecial manner with the parts affected; they decay and decompoſe, they die and become fœtid. The decompoſition which the teeth ſuffer by death, is ſtrongly illuſtrative of the living and preſervative power they before enjoyed. It is by virtue of this living power that the practice of tranſplanting teeth is founded. The inoſculation that enſues cannot take place between living gums and dead teeth, nor between living teeth and dead gums, but between living parts altogether with each other. It was by virtue of this tendency that living parts have to unite, that Mr. Hunter inoſculated living teeth upon the comb of a cock, &c, &c.

Theſe are the inſtruments which are deſtined to comminute ſolid food, in order that it may be fit for the ſtomach to aſſimilate. Theſe teeth, however, are very delicate in their fabric and appearance, and therefore are called milk-teeth: about the ſeventh or eighth year they progreſſively crumble and decay. A ſecond ſet, more durable, more compact, and more extenſive, ſupplies their place. The ſame number of inciſores and canine are replaced, but there are four molares added to each jaw; and after the age of puberty has been attained, there are two more added to them, completing in all thirty-two.

In the healthy and temperate, theſe teeth are deſtined to continue firm and undecayed during the long period of a long life, for the purpoſe of dividing the ſenſible properties which ſolid matter contain.

Of the ſalivary Glands, by which the ſenſible Properties of Food are modified with reſpect to Quality.

While the ſenſible properties of ſolid food are deſtroyed by the proceſs of maſtication, the qualities it contains undergo ſome modification, by the action of different fluids, which are perpetually diſcharged into the mouth from ſeveral glands: theſe glands are ſix in number, the two parotid, the two ſublinguales, and the two ſubmaxillary, whoſe excretory ducts open into different parts of the mouth. It is probable that liquid food, of a bland and mild nature, has not the power of exciting them to act; it is ſolid food alone, or liquid food, which poſſeſſes ſenſible properties in an high degree, that cauſes them eſpecially to act, and by that action to produce mucus and ſaliva.

That the ſenſation which the nerves experience in conſequence of this ſtimulus, is the cauſe by which the glands are excited to act, ſeems evident from the effect of imagination alone: they continue torpid, or become active,

in

in proportion as the mind alone dwells upon objects that either diſguſt or pamper the appetite. They become torpid by hunger, by diſeaſe, and certain paſſions of the mind. They become excited by the ſalaciouſneſs of the imagination: ſecretion enſues, and a plenitude of ſaliva flows into the mouth, more eſpecially if it be aſſiſted by the proceſs of manducation.

Various attempts have been made to aſcertain the quantity of ſaliva which is produced during each meal: it is however very evident, that it muſt vary ſo much under different circumſtances, as to render the calculation very uncertain. In its natural and healthy ſtate, it is a clear inſipid fluid, deſtitute of any ſenſible properties, and, as far as we are able to judge, incapable of acting upon the food by virtue of any chemical qualities it may contain: by chemical analyſis it is found to be compoſed of ſerum, of a colourleſs mucilage, and ſome ſaline matter involved in it. The ſaline matter appears to be principally ſea ſalt, becauſe cubic cryſtals are evidently to be ſeen in the reſiduum after evaporation. There are other cryſtals again that are double pyramids, each of four ſides, —cryſtals the ſame in form as thoſe of common ſal ammoniac. It is however very evident that in an healthy ſtate theſe ſalts are in a latent condition, becauſe the ſaliva is altogether inſipid. On the contrary, when a morbid ſecretion enſues, when the ſaliva is in a ſtate of decompoſition, theſe ſalts, which the ſaliva involves, act by virtue of their ſenſible and chemical qualities, imparting to the taſte a ſaline ſenſation. Erroneous however muſt be the idea of thoſe who take the morbid condition of parts as the teſt by which they are to explain the manner how the healthy actions are carried on.

Wiſhing to aſcertain whether the ſaliva had any ſolvent effect upon the food, and whether it acted by virtue of its fluidity alone, I made the following experiments: I received into a glaſs four ounces of ſaliva (from a lady who was ſeized with a ptyaliſm, after ſcarletina, although ſhe had not taken a particle of mercury), and four ounces of diſtilled water in another glaſs, and put in each one cubic inch of bread. In twenty-four hours, the bread that was immerſed in the ſaliva had ſuſtained a pretty copious precipitation. The precipitation, which was apparently of a white flow-cry nature, was conſiderably increaſed at the termination of the third day; the whole ſeemed to preſerve its ſweetneſs: on the fifth day the ſaliva became ropy, an extrication of air took place, giving out an offenſive odour. (Thermomer 60.)

The bread which was immerſed in the water continued unaltered for the firſt twenty-four hours; in forty-eight hours a ſmall quantity of farinaceous matter was precipitated; gaſeous matter was then extricated, imparting to the olfactory ſenſe an acid flavour.

I expoſed two bits of raw mutton to ſaliva and diſtilled water, as in the former experiments (the ſaliva I obtained from a patient who had a ptyaliſm from the exhibition of mercury). It ſeemed to me that the meat which was in the ſaliva was much ſofter for the two firſt days than that which was in the water, although in both it ſeemed to preſerve its ſweetneſs: on the third day, the ſaliva began to be ropy, and the meat to ſtink. On the contray, the fleſh which was in the water did not ſeem to have undergone ſo conſiderable a change; it continued freſh for two days more. I expoſed different kinds of meat, dreſſed in different ways, to the action of ſaliva; and in all I found that it was always conſiderably ſoftened before it gave out any vapour. That the ſaliva does poſſeſs a ſolvent property in a ſlight degree, is alſo probable from the action which it exerts upon ſome metallic ſubſtances. If they are merely applied to the tongue, and then removed, they are inſipid, becauſe inſoluble by its power. On the contrary, if they are allowed to remain in the mouth a ſufficient time to be acted upon by the ſaliva, they become in a ſlight degree diſſolved, and are therefore found to be ſapid to the taſte.

Whilſt the food is broken down, with reſpect to maſs, by the action of the teeth, the ſaliva is deſtined to aſſiſt them in comminuting thoſe parts into ſmaller particles: it would therefore ſeem that it is the ſecond ſtep which the food undergoes in the proceſs of aſſimilation, and that it becomes in harmony with the parts through the ſalivary and mucous media in which it is involved.

It is not the ſenſible properties of food, in point of quantity alone, that it is neceſſary to deſtroy: it appears equally if not more eſſential that the ſpecific or chemical qualities ſhould be eliminated alſo. and it is this preliminary proceſs for which ſaliva is eſpecially deſigned. The action of the ſalivary glands is exerted, in conſequence of the ſtimulating qualities which food contains, not ſolids only, but fluids alſo; it bereaves acids of their acidity—alkalis of their acrimony; and to a certain and limited extent it blunts the aſperity of both, rendering them bland and mild *.

When the food has undergone this proceſs, by the aſſiſtance and motion of the tongue and mouth it is formed into a morſel; the capacity of the mouth is diminiſhed by the elevation of the top of the tongue upon its roof. Its contents are therefore propelled into the fauces. By the action of the velum pendulum palati, the food is prevented from getting into the noſtrils—into the trachea, by the preſſure it produces upon the epiglottis, in conſequence of the epiglottis

---

* It were ſuperfluous in this place to point out the evil that frequently ariſes to many from the dirty and pernicious habit they have of exciting the action of the ſalivary glands, for the purpoſe of ſpitting out the ſaliva; I ſhall merely add, that it is a frequent cauſe of dyſpepſia.

tis

itſelf being at that time drawn down over the larynx. And finally, it is prevented from regurgitating into the mouth, by the motion and poſition of the tongue, and of the muſcles by which the fauces are contracted (the conſtrictores iſthmi faucium). It is therefore thruſt down from the pharynx into the œſophagus; the aperture of which is ſuſceptible of conſiderable enlargement by the action of different muſcles that are attached to it.

The *œſophagus*, or gullet, begins where the pharynx ends; it proceeds in a triangular ſpace behind the mediaſtinum, and, after paſſing through the diaphragm, terminates in the cardiac or left orifice of the ſtomach.

The œſophagus is compoſed of an external mucous membrane, of a middle and muſcular coat, and is externally covered by a tunic which it principally derives from the pleura.

The food is propelled through the œſophagus into the ſtomach, by the power of its muſcular coat; it is diminiſhed in length by the action of its longitudinal fibres; it is contracted in breadth by the action of the circular fibres, with which its internal ſurface abounds. And finally, its internal diameter is completely obliterated by the compound action of both. The food is therefore propelled by a kind of periſtaltic motion from the mouth, where it was comminuted, through the œſophagus, where its temperature is accommodated, into the ſtomach, in which it is to be digeſted*.

---

* It occaſionally happens that the voracity of the appetite leads men to ſwallow very large portions of ſolid matter, and that bones are introduced of greater dimenſion than the œſophagus can convey. It is a very common practice to attempt to thruſt them down by means of the probang. I muſt obſerve, that I have ſeen a preparation in the poſſeſſion of a gentleman, where the raſhneſs of the practitioner, in conſequence of the effort he made, inſtead of thruſting the bone into the ſtomach, forced it through the œſophagus; the event of which proved fatal in a ſhort time.

CHAP. IX.

OF THE STOMACH.

The fabric of the ſtomach deſcribed—deſtined to be a ſecretory organ for the production of gaſtric juice—its qualities—its power—its uſe aſcertained and proved by the experiments of Dr. Stephens, Mr. Hunter, &c. &c.—The different degrees of aptitude in different ſpecies of food proved—the relation which it bears to the food—the aſſimilation of the food—how forwarded—how retarded—the action of the food upon the ſtomach—the operation of medicine—poiſons, &c. &c.

WHERE the œſophagus terminates, the ſtomach begins: it is ſituated in the cavity of the abdomen under the diaphragm: the external coat is compoſed of a duplicature of the peritoneum, which is connected internally with the middle or muſcular one.

The muſcular coat of the ſtomach appears compoſed of fibres arranged in different directions: the fibres of the external layer are of a longitudinal form, running from the cardiac or left orifice of the ſtomach, where the œſophagus terminates, to the right or pyloric orifice. Within this there are fibres which aſſume a diagonal form, and which are covered over by a layer of others that take a circular or tranſverſe direction.

At the pyloric orifice of the ſtomach theſe muſcular fibres ſeem to be congregated together in a circular form, conſtituting in fact, with the addition of a ligamentous band, a ſphincter muſcle. And finally, the muſcular coat is covered over internally by a mucous or villous one: the ſtomach is ſupplied with nerves from the par vagum and intercoſtal; with blood veſſels from the divided trunk of the ciliac artery which I have already deſcribed. The diviſion of theſe trunks into branches, and the ſubdiviſion of theſe branches into fibrils, are evidently deſigned to allow none but the rareſt and moſt ſubtle parts of the blood to flow through. Theſe veſſels, after paſſing through the peritoneal and muſcular coats of the ſtomach, terminate either within or on the ſurface itſelf of the villous coat.

It has been a queſtion amongſt anatomiſts, whether the villous coat of the ſtomach conſtituted a gland, by the power of which the blood it received was acted upon and changed; or whether it was the matrix only for the attachment of different follicles, which it is ſuppoſed by ſome are ſituated on its ſurface. If, however, the arteries of the ſtomach be injected, the whole of the internal ſurface is completely filled, and ſcarce any interſtitial ſpace can be diſcovered uninjected. If glands therefore do ſubſiſt, they are ſo minute, numerous and proximate, that the whole villous coat of the ſtomach may be conſidered as of a follicular ſtructure.

Although this conſtruction may be doubted and diſputed by ſome, the fact, I believe, is now admitted by all, that the blood which the veſſels convey, and which is depoſited in the internal ſurface of the villous coat, receives, and becomes in conſequence endowed with, powers of which it was totally deſtitute before, conſtituting a fluid known by the appellation of *gaſtric juice*; by the energy of whoſe power the aſſimilation of the food is effected. If the food be dead, by the power of the gaſtric juice it loſes its chemical properties, and becomes animated; if it be received alive, it becomes killed and animated anew, loſing the living properties it originally contained, and is aſſimilated to the one and only ſpecific

cific nature of the ſyſtem by which it is received.

That the gaſtric juice has the power of acting upon the food which is introduced into the ſtomach, and of deſtroying the ſenſible or chemical qualities it contains, not only organized matter but diſorganized, not only living but common, is a fact eſtabliſhed by a multitude of experiments, performed not only in the body but out of the body. I ſhall avail myſelf of the light which Reaumur, Mr. Hunter, Dr. Stephens, Spallanzani, &c. have thrown on the ſubject, by a number of ſatiſfactory and judicious experiments and obſervations which they have ſeverally performed and made.

Monſieur Reaumur long ago being ſolicitous to know what alteration the food ſuſtained in the ſtomach, encloſed a quantity of animal food wrapt up in rags, or encloſed in ſmall metallic tubes. Some of theſe tubes were ſo perforated that they could eaſily admit the paſſage of any fluid into them, and combine with their contents; others again were intact and imperforated. They were then introduced into the ſtomach of a carnivorous animal: after a given time the tubes were voided; but upon examination it was found, that the animal matter which was in the perforated tube was diſſolved, whilſt that which the imperforated one contained, had undergone little or no alteration.

The ſolution which the food underwent in the ſtomach, and the converſion which different ſpecies of matter ſuſtained into one kind when expoſed to the action of that organ, were facts too important to be overlooked by the penetrating, although I will ſay uncultivated genius which the late Mr. Hunter poſſeſſed. However erroneous his concluſions in many inſtances may have been, and however true it may be that he ſaw through a glaſs darkly, it muſt, however, be admitted, that it is to him we are indebted for having revived the doctrine which aſcribed to the principle of life the power of organization, and to the organization of living parts the efficiency of the actions they performed, excluding altogether the agency of chemical powers in the proceſs of aſſimilation *.

It

---

* It is impoſſible to contemplate the character of Mr. Hunter without being ſtricken with the originality he poſſeſſed.

It was, I believe, in the Philoſophical Tranſactions of the year 1772, that he publiſhed his obſervations upon the ſubject of digeſtion, and in which he pointed out the power the gaſtric juices poſſeſſed, not only of acting upon food, but upon the ſtomach itſelf, after the ſpecific actions of life were terminated; and in the number of comparative experiments he made, he was led to behold the change which ſubſtances of the ſame kind underwent when expoſed to the actions of the ſtomach. It was notorious that carnivorous animals having a membranous ſtomach, as fiſh that uſed to live upon eels and other ſmaller fiſh, that when one part remained in the throat and mouth, the other introduced in the ſtomach, whilſt the former

---

poſſeſſed. Uneducated in his youth to the profeſſion, his genius too cramped and oppreſſed by the jealouſy and deſpotiſm of an elder brother, whoſe reputation was raiſed and eſtabliſhed by Mr. Hunter's labour and induſtry; he notwithſtanding lived long enough to be at the head of the profeſſion which he ornamented and improved, and ſhewed the path to the attainment of truth, by referring the phenomena which the animated ſyſtem diſplays to the living power it contains. He has, it is true, been attacked and inſulted by thoſe who were fit only to ſerve as his *footſtool.*

was unaltered, the latter was in a pulpy and nearly diſſolved ſtate. He was therefore led to believe, that the act of digeſtion depended on a proceſs of ſolution; not the ſolution of the ſtomach by the gaſtric juice whilſt the powers of life continued, but the action of the gaſtric juice upon the food alone.

When the preſervative properties of the ſtomach were weakened, Mr. Hunter thought that the gaſtric juice had itſelf the power of acting upon, of eroding, and of diſſolving it alſo, although before it was capable of reſiſting its operation.

That the gaſtric juice poſſeſſes the power of killing living animal matter, and of diſſolving it, is farther proved in the moſt eminent degree by the changes it undergoes when introduced into the ſtomach of ſerpents. Theſe animals neither ruminate nor maſticate, but gulp and ſwallow down the morſel wholly and undivided. They have been known to devour men, women, and children, very frequently pigs and deer; and inſtances, as I have I believe already ſtated, are recorded, where a young buffalo has been found within their œſophagus and ſtomach *.

Such is the active power which the gaſtric juice contains, that a comminution and ſolution by it of the whole animal enſues ; it is bereaved of the living property it originally poſſeſſed, and becomes changed and aſſimilated to the nature of the ſyſtem to which it is applied.

In the year 1777 Dr. Stephens publiſhed at Edinburgh a Diſſertation on Digeſtion, that gained him much credit. His proofs were numerous and ſatisfactory ; not confined to the human ſubject alone, but extended to different claſſes of animals.

Firſt, he choſe thoſe that had ſtrong muſcular ſtomachs, as fowls, turkeys, &c. He

---

* It is proper to obſerve that their mouth is ſuſceptible of wonderful enlargement, and that the œſophagus and ſtomach ſeem to conſtitute in them one cavity alone. I think it however more accurate to ſay that it is all ſtomach ; although I know ſome anatomiſts, whoſe accuracy I reſpect make a diviſion of this part into two ; but allow that thi partition is ſo ſlight, that the gaſtric juice can eaſily flo from the ſtomach, ſtrictly ſo called, into the œſophagus If, however, it be admitted, that the food becomes aſſimilated by the gaſtric juices in the œſophagns, I think more correct to ſay that it is one and the ſame organ.

there ſaw the power which the gizzard poſſeſſed of triturating the food. He, however, was able to aſcertain that this proceſs was merely a preliminary one to the more perfect ſtate of aſſimilation by the membranous ſtomach.

Secondly, he choſe thoſe whoſe ſtomachs were not ſo complicated and ſtrong as the granivorous birds, but thoſe that were notwithſtanding very active and muſcular, ſuch as the crow and raven. He was able to collect from the ſtomach of theſe animals a quantity of gaſtric juice by means of a ſponge, which he thruſt into their ſtomachs; and after leaving it there for ſome time he drew it out, and by that means obtained a quantity ſufficient to aſcertain its properties. It was bland and mild to the taſte, neither alcaleſcent or acid; neither turning vegetable blues to a green or to a red colour.

The quantity of gaſtric juice which he procured he encloſed in a phial, and filled another with diſtilled water: in both of theſe he put portions of meat alſo, and expoſed them to the ſame degree of heat: the meat that was immerſed in the water underwent little alteration, but that portion of it that was immerſed in the gaſtric juice became ſoftened, and ſoon after reduced into a pultaceous maſs. If the ſolution was not complete, it can be eaſily accounted for, by the ſmall quantity of gaſtric juice that was collected, and the loſs it ſuſtained of its original and ſpecific power by departing from the ſtomach by which it was produced, as the ſeat in which it was deſtined to act. The fact, however, appeared ſufficiently eſtabliſhed, that the gaſtric juice poſſeſſed a ſolvent power over the food, and that it did not ſeem to ariſe from any chemical property which it contained, being deſtitute, as far as could be judged, of any ſenſible qualities.

At the time that Dr. Stephens was proſecuting theſe experiments upon carnivorous birds, there was a poor man who uſed to ſwallow a number of ſtones, and, by affording diverſion to the people, obtain from them the means of ſubſiſtence. The opportunity was not to be neglected; it was eagerly ſeized by Dr. Stephens; and the ſtone-eater, by confidence that nothing prejudicial to his health would be given, was prevailed upon to ſwallow a number of ſubſtances, with a view of aſcertaining the alteration they ſuſtained in the ſtomach.

A leech was introduced into a ſmall ſilver ſphere perforated with holes, and ſwallowed; and after remaining in the ſtomach ſome time it was voided: it was however found, that the whole of the leech was diſſolved, ſaving a ſmall quantity of black matter in a pultaceous ſtate.

Wiſhing to aſcertain the aptitude to be digeſted which different ſpecies of food poſſeſſed, he introduced into a ſphere perforated with holes, and ſeparated into two parts, pieces of mutton and of fiſh. He found by experiment, that the fiſh in general was ſooner and more completely diſſolved than the mutton. And finally, he tried the alteration which meat ſuſtained when introduced in a raw ſtate, or that which had undergone a culinary proceſs: he was, however, ſatisfied, that the former was far more difficult of digeſtion than the latter; that, whilſt the one continued unaltered, the other was nearly diſſolved. He found the ſame degree of difference to ſubſiſt between animal and vegetable food, and concluded that the former was more eaſily digeſted than the latter.

That animal or vegetable matter is more difficult to aſſimilate whilſt it retains its active and living properties, than when they are diminiſhed or loſt, is proved in the example we frequently behold of worms: theſe animals often exiſt in the ſtomach in an active and in a living ſtate, reſiſting the operation of the digeſtive organ; on the contrary, there can be no doubt but that, after they have been evacuated, if they were prepared by proper culinary means, they would then eaſily be acted upon and digeſted. It is owing to the ſame cauſe that meat in a crude and raw ſtate ſeems more difficult to be digeſted than after it has been kept for ſome time; when the living and preſervative properties of its own which it contains become ſo far weakened, that inſtead of reſiſting, it immediately yields to the operation of the gaſtric juice, and becomes aſſimilated by it. It is with a view to this circumſtance, that we are in the habit of keeping meat ſome time after it has been killed, before it is ſerved up for food; that mutton and veniſon,

niſon, &c. whilſt they are freſh and tough (becauſe the principle of life binds and keeps all the parts connected together) are difficult of digeſtion: on the contrary, that they are moſt eaſy of digeſtion, after they begin to loſe their preſervative properties, when the bond of their elementary parts is looſened; when they become conſequently tender, their latent properties made ſenſible, and impart to the guſtatory ſenſe a *goût*, or high flavour. It is owing to the comparative degree of weakneſs by which the parts of young animals are held before they have been properly evolved, that they are more tender and more eaſy to be digeſted, more abounding with interſtitial fluid or gravy (that very ſubſtance which Mr. Hunter himſelf could never coagulate), than the fleſh of the old. This is more eſpecially the caſe if they are lean and impoveriſhed, and conſiſt of ligamentous matter only and animal fibres, but are deſtitute of thoſe juices which ſeem to poſſeſs the higheſt degree of aptitude to be acted upon by the ſtomach, and conſequently to afford nouriſhment to the ſyſtem;—that poſſeſs more of quality than of quantity; and which would ſeem neceſſary for the proper aſſimilation of the more ſolid parts.

The power of the gaſtric juice to aſſimilate vegetable matter, is proved by facts equally ſtrong as that of animal. It is proved by the whole race of Bramins, who live upon vegetables alone: there ſeems, however, a difference in the degree of aptitude which it poſſeſſes of being acted upon and converted.

It is owing to the vital and preſervative properties of vegetables, and of unripe fruits, that, inſtead of being acted upon by the gaſtric juices, they generally reſiſt their operation. We all know the morbid effects that are produced by eating unripe grapes, green plums, young currants, &c. &c. &c. although when they have arrived at maturity, when their vegetative power is ended, and when they are even verging to decay, we then find that they prove highly nutritious and wholeſome. So important indeed does it appear that the bond of vegetable and of animal matter ſhould be looſened either by the natural proceſs of vegetable decay, or more eſpecially by a culinary proceſs, that moſt of the vegetable ſubſtances which we daily receive as food, are found in their raw ſtate particularly obnoxious to the human frame, as raw potatoes, raw carrots, &c. &c.*

That the gaſtric juice poſſeſſes the power of animating common matter, is proved by facts equally univerſal and ſtriking. It is proved by experiments made on fiſh that have been kept in cloſe veſſels, and made to ſubſiſt on water and air alone. After theſe ſubſtances had been aſſimilated, and formed a part of the ſyſtem, they then became ſuſceptible of undergoing the proceſs of putrefaction. It is illuſtrated by vegetables, that live on water and air alſo: it is illuſtrated by men who are in the habit of taking, and I may ſay, of ſubſiſting upon ſpirituous liquors almoſt entirely.

---

* It may be important to relate a fact that happened at the beginning of laſt war, on board of the Blonde frigate, ſoon after the evacuation of Boſton by our troops, when there were no freſh proviſions to be procured, and ſhe was ordered to cruize during the winter months off the more northern coaſts of America. From the ſeverity of the ſeaſon, from fatigue, and continued uſe of ſalt proviſions, the crew were ſeized with a ſcurvy of the moſt malignant kind, which carried off many of them every day. The ſurgeon, an intelligent man, alarmed at the ravages the diſeaſe produced, and at the ſame time deſtitute of the uſual means by which it could be alleviated, at length diſcovered that there were ſome few potatoes on board; he ordered ſmall ſlices of them to be cut, and ſmeared over with melaſſes. Theſe were given to the men; and to his aſtoniſhment, the mortality not only ceaſed, but thoſe who were ill abſolutely recovered.

And finally, that the gaſtric juice poſſeſſes the power not only of killing living, but of reanimating dead matter, was proved by ſome experiments made, I believe, by Mr. Hunter and Spallanzani. They thruſt pieces of putrid fleſh, tied by a ſtring, into the ſtomach of ſome dogs; and after leaving it ſome time in that organ, they withdrew the meat; and found upon examination, that from being offenſive it had become ſweet, from being putrid it was freſh again. It is not therefore ſufficient for the food, by the organs of ſenſe to have been ſelected, by the teeth to have been comminuted, by the mouth to have been maſticated, by the ſaliva to have been blunted and blanded: it is by the active energy of the ſtomach alone, and the fluid it ſecretes, that it becomes digeſted and aſſimilated, that ſolid food is reduced to a fluid ſtate, that it becomes killed as it were, and loſes its old life, and then is animated anew, receiving from the living power of the gaſtric, the participation of life from the ſyſtem to which it is applied*.

When this effect has been produced, when aliment has been converted and aſſimilated, it then loſes its name, and receives the appellation of CHYLE, poſſeſſing properties totally different from the ſubſtances of which it was formed. If it were made out of the moſt antiſeptic matter, it then becomes liable to putrefy; and if it be made out of the moſt putrid ſubſtances, after it has been animalized it becomes poſſeſſed of antiſeptic power †.

It

---

[*] That the food we receive muſt be killed by the ſtomach before it is vivified afreſh, is evident from hence: If it retained its own living power in an eminent degree, it is poſſible to conceive that it might inoſculate with the ſtomach, inſtead of being digeſted by it; and if it retained its living power without inoſculating, the nature of that food would be always apparent: we ſhould participate of the quality of the beaſts on which we feed, and of the vegetables alſo.

[†] No doubt can exiſt, that the pigs which grubbed their way into the ditch which encloſed the Cimetiere du Couvent des Innocens à Paris, and which were ſleek and thin before they went in, and came out wallowing in their fat, in conſequence of the putrid fleſh which had been there for years, and which they devoured;—no doubt,

It is by the power which the ſtomach poſſeſſes of ſecreting from its internal ſurface gaſtric juice, and from the living and converting power which the gaſtric juice itſelf contains, that it deſtroys the ſenſible properties of the aliment conveyed to it, whilſt it retains its own: it changes things external to itſelf, without being changed by external things.

In the infinite multitude of ſubſtances for food which we employ, no doubt can exiſt but that ſome there are that have a greater aptitude than others to be acted upon and digeſted,

doubt, I ſay, can exiſt, but that their fleſh poſſeſſed preſervative properties in as eminent a degree, as if they had been fed upon the beſt hog-waſh from the beſt dairy in the county of Surry. There is not a cowſlip in a field, nor a peepee corner in any part of the city, but which affords the moſt luxurious nouriſhment to a variety of animals. Although the food they devour is dead and putrid, the ſyſtem itſelf, to which theſe matters afford nouriſhment, poſſeſſes preſervative properties in the moſt eminent degree. Nothing indeed can be a ſtronger proof of the truth of the principles I have endeavoured to eſtabliſh, than that in the great theatre of the world, corruption ſeems to be the matrix for animation—not that animation ariſes out of corruption, but that corruption which is produced after different animated ſyſtems have attained and fulfilled the final cauſe of their exiſtence, becomes the proper food for the evolution of a new race.

and that conſequently more readily afford nouriſhment and ſupport to the animated ſyſtem, in many circumſtances, brandy and wine more than milk or water, and animal food more than vegetable. It is however to theſe ſeveral claſſes of things in particular, which are ſuſceptible of converſion by the ſyſtem to which they are given, that the title of *Nutrientia* ought to be applied; the cordial and nutritious effects they impart, depending altogether upon the relation of aptitude which they bear to the aſſimilating power of the ſtomach.

That they poſſeſs nothing *abſolutely* (in the abſtract) nutritious in themſelves, but only with relation to the animated ſyſtem, is evident from this, that they neither produce a cordial nor a nutritious effect during a ſtate of ſyncope, or of ſuſpended animation. It is only when the nervous energy continues in force, or when it returns after having been ſuſpended, that the different articles of food produce a ſalutary or beneficial effect to the animated frame.

When the ſtomach has not the power of aſſimilating the food it receives, either the food retains its own properties, or undergoes the ſame changes in the ſtomach, as it is prone to do out of it; or elſe it acts upon the ſtomach, inſtead of being acted upon by the ſtomach; and a cauſtic and poiſonous effect is thus produced. It is owing to the preſervative property which particular ſubſtances poſſeſs, that they reſiſt the action of the ſtomach altogether, and therefore are deſtitute of every nutritious quality whatever; and continue in the organ in a dormant ſtate ſo long as they are deſtitute of any ſenſible or active qualities. For example, a globule of mercury, and pieces of different metals may continue in the ſtomach for a conſiderable time without benefit or detriment to the ſyſtem: but if a quantity of acid were introduced, and the ſolution of the metal effected; the compound that would be formed, inſtead of continuing paſſive and dormant, as the metal alone does in its ſimple ſtate, the compound that was formed would act upon the ſtomach by virtue of its chemical (or ſenſible) qualities; and either excite the contraction of its muſcular coat, in order that the deleterious ſubſtance might be expelled, or elſe it would act upon the part in which it was in contact, corrode and deſtroy it, and thus produce a cauſtic or poiſonous effect. Thus then it is that we have the diſtinguiſhing characteriſtics of different ſubſtances, known by particular names.

Of aliment, or ſuch things that are eaſily aſſimilated by the ſtomach, without the ſtomach being acted upon by them.

Of condiment, or ſuch things that poſſeſs quantity without quality, that, without offending from their quantity, are deſtitute of any quality by which they can be aſſimilated.

Of medicines that act upon the ſtomach whilſt they are at the ſame time acted upon by it.

Of poiſons, that not only reſiſt altogether the action of the ſtomach, but poſſeſs the power of acting upon, corroding and deſtroying its fabric, either from qualities chemical—from quantity mechanical—or both.

It is owing to the particular mode of irritation which particular medicines produce upon the ſtomach, and the change which the ſtomach itſelf conſequently ſuſtains, that antimonium tartarizatum is found generally to produce emetic effects. On the contrary, why rhubarb, jalap, ſcammony, gambouge, colocynth, and the different reſinous and metallic ſubſtances chemically combined, inſtead of an emetic[*], generally produce a cathartic effect. And finally, it is owing to the nature of ſpecific poiſons alſo, that they have their ſpecific mode of irritation and of deſtruction. I have opened three patients that had been poiſoned with hemlock[†]. It generally produced moſt violent vomiting and purging, and diſſolution in a few hours was the conſequence. I found different portions in the ſtomach maſticated, but otherwiſe unchanged; whilſt, on the contrary, the ſtomach itſelf was generally covered with a number of purpliſh ſpots like vibices.

The unhappy victims that had fallen a prey to the effects of arſenic have been more numerous. In all, the burning and lacerating pain it produced was moſt exceſſively excruciating; the thirſt was moſt exceſſive, the tongue and throat were parched with heat; the limbs were frequently convulſed; the reſpiration generally frequent; the ſurface of the body conſiderably diſtended and ſwelled.

---

[*] It is an obſervation made by Dr. Webſter in his Facts and Obſervations, &c. "that the ſtomach may be put into a ſtate more or leſs ſuſceptible of a particular impreſſion. Mercury, whether adminiſtered internally or externally, ſeems to render it more ſenſible to that of the bark in ague, of ſquill in dropſy, of opium in ſyphilis, and of electricity in various diſeaſes."

[†] In the caſes to which I allude, the hemlock had been eaten through miſtake: it was ſuppoſed to have been a parſnip.

Although it commonly happens that a portion of the poiſon is evacuated, a quantity generally remains either in the ſtomach or in the inteſtines within the folds of the valvulæ conniventes. Marks of inflammation are for the moſt part viſible; increaſed quantities of mucus, ſometimes purulent matter, and frequently ſphacelated ſpots are apparent; and the whole fabric of the ſtomach is ſo extremely ſoftened that it is eaſily torn through. Theſe poiſons, and others of a ſimilar kind, we have no means of correcting or rendering abortive: the only method that can be adopted is plentiful dilution with mucilaginous and oily fluids, with a view of ſheathing the ſurface of the organs from the immediate contact of the offending cauſe, and to ſerve as a vehicle by which it may be expelled: to abate inflammation, to ſoothe pain by external fomentations, and to endeavour to evacuate the poiſon from the ſyſtem.

There is however a large claſs of mineral ſubſtances, that prove highly poiſonous either in their native ſtate, as the cauſtic alcalis, or as many of the different mineral acids, either ſimply, or when combined with metals; and where the activity of the poiſon may be weakened and neutralized—alcalis by acids—acids by alcalis. I recollect a caſe ſome time ago, to which I was called, where a moſt amiable and reſpectable woman in a pregnant ſtate, the mother of a numerous family, took three large tea ſpoon-fulls of white precipitate by miſtaking it for magneſia. Cholera morbus was immediately produced, and a portion of it was no doubt evacuated: a burning pain in the mouth, throat, œſophagus and ſtomach, however, continued. I made her dilute moſt plentifully with warm water, giving her frequent doſes of ſoap in a ſtate of ſolution. After having endeavoured to evacuate as much of the poiſon as could be done, inflammation however took place to a certain extent, followed by ſalivation. I am happy, notwithſtanding, to ſay, that abortion did not enſue, and that ſhe perfectly recovered *.

It is not the introduction of particular mineral poiſons alone that impede and deſtroy the digeſtive power of the ſtomach. The digeſtive functions of the ſtomach are impaired by taking in exceſs ſome of thoſe ſubſtances which prove ſo very ſalutary to the ſyſtem when taken in moderation. I ſhall

---

* The miſtake aroſe from a cauſe that cannot be too generally known, in order that it may not be again incurred. She ſent her footman (an Iriſhman) to a chemiſt, where he had been before for the ſame article, for a quantity of magneſia. The fellow forgot the name, and aſked for white precipitate. It was therefore mixed up with water, under the ſuppoſition of being magneſia. The lady obſerved at the time, that it was very heavy, and mixed badly. It was however ſwallowed, and the error detected by the effects produced. It is wonderful what miſtakes are committed by men unaccuſtomed to the names and properties of medicine, and how cautious people in general ought to be, when they ſend for any medicine whatever. I recollect a gentleman ſending for two ounces of *tartar emetic* inſtead of two ounces of *cream of tartar*. Fortunately for him, the quantity was ſo conſiderable that it could not be procured in the country town in which he reſided. Had it been in London, the event would probably have proved fatal to him.

not at preſent trace the progreſſive changes which the ſtomach is made to undergo from the conſtant and habitual introduction of ſpirituous liquors, and the ultimate effect which they have upon the ſyſtem at large. I ſhall merely ſtate the poiſonous and moribund effect that a large quantity produced when ſuddenly taken. Seven brickmakers, who were, as I was informed, in perfect health before, after their work, adjourned to a public houſe in the neighbourhood, and drank a large quantity of ſpirits. (I could not have the preciſe quantity aſcertained.) After leaving the public-houſe, they went into the field where they uſed to work, and which was contiguous to it, and ſlept on a quantity of ſtraw. Early in the enſuing morning they were diſcovered. It was however found impoſſible to rouſe five of them, although every effort was made for that purpoſe. They therefore fell victims to the active power of the ſpirit, and the relative weakneſs of the ſyſtem to reſiſt its operation. The other two had ſome ſmall veſtiges of vital action remaining, manifeſted by a very ſlow and almoſt inſenſible reſpiration; by a pulſe very low and indiſtinct: the ſenſibility of the ſyſtem was ſuſpended, and the ſurface of the body was perfectly cold. I immediately ordered friction to the whole ſurface ; I inflated the lungs, and at length got down a quantity of warm water, with a view of diluting the concentrated ſtate of the ſpirit which the ſtomach contained. By theſe means the circulation became reſtored—the ſtomach diſcharged its contents, and both the men recovered.

Theſe were the effects that enſued in conſequence of the ſudden introduction of ſpirituous liquors into the ſtomach. The operation they produced was not by cauſing indirect debility through the medium of excitement, and thereby exhauſting the excitability of the ſyſtem, according to the Brunonian doctrine. On the contrary, they produced debility by preventing excitement ; they aboliſhed excitability before excitement could begin. This was the lot that fell to the author of the ſyſtem himſelf, when he put it in practice on himſelf ; he was found ſnoring away his laſt breath under the immediate operation of his moſt diffuſible ſtimuli, or *life-producing cauſes.* Poiſons, therefore, are not merely the negative but the very oppoſite to aliment, not merely in not poſſeſſing the aptitude to call forth the action of the ſtomach, to be acted and aſſimilated by it, and thereby conferring nouriſhment to the ſyſtem: but they are the very reverſe of this in their operation; they not only do not afford it nouriſhment, but they prevent its action by impairing or deſtroying the organization of the parts, producing death either mediately through diſeaſe, or immediate death.

It is not theſe various ſubſtances alone that weaken and deſtroy the digeſtive power of the ſtomach: it is weakened and deſtroyed by mental exertion in exceſs and corporeal fatigue. That corporeal fatigue has a tendency to weaken and to impede the digeſtive proceſs, is evident from the collected obſervations of every one. It has however been proved in a very decided manner by Profeſſor Harwood. He had two dogs of the ſame ſpecies, that were in the plenitude of health, and which he fed in the ſame way. After having given them a plentiful meal, one of them was left at home, laid down before the fire, and fell aſleep. The other was taken out and hunted for a few hours. As ſoon as it returned home, both dogs were killed, and their ſtomachs examined. The dog that had been aſleep had the food digeſted. On the contrary, the food in the ſtomach of the one that had been hunted was found undigeſted, and nearly in the ſame condition as it was when firſt introduced.

Of the Sympathetic Affections of the Stomach.

It is impoſſible to behold the relation that ſubſiſts between the food and the ſtomach, between the ſtomach and the mind, without lamenting the ignorance we poſſeſs of the nervous ſyſtem, and the dependence that ſubſiſts between the nerves that are diſtributed upon particular organs and the brain, to which they ſeem in a conſiderable degree ſubſervient. No doubt can ſubſiſt but that the ſalivary glands ſympathize at particular times with the organs of ſenſe, and the ſtomach itſelf with the ſalivary glands, producing to the mind either deſire or averſion, the appetite of hunger, or loathing and nauſea. That there is a larger quantity of gaſtric juice ſecreted when the mind is in a ſtate of hilarity and contentment, than when it is depreſſed or oppreſſed, is evident from the variety we behold in the act of digeſtion. In the one caſe, the aſſimilating proceſs takes place in a very regular and perfect manner; in the other, it is effected imperfectly and inefficiently. Although the food may have been ſo far acted upon as to have had its preſervative powers weakened, it has not received in a ſufficient degree the living power of the gaſtric juice. If it be vegetable food, it ferments and turns ſour; if it be animal matter, it putrefies and becomes offenſive: and from both there is a quantity of gaſeous matter extricated, which diſtends the ſtomach, and is generally expelled by the proceſs of hiccuping. A certain teſt, I ſay, that the food has been killed, and loſt its own preſervative properties, without having been aſſimilated and vivified anew. This effect is generally produced from the introduction of improper aliment, or from the weak ſtate of the ſtomach, although food may have been taken that at other times proved ſalutary, and was with facility digeſted.

It appears that the digeſtive powers of the ſtomach are not only impaired and ſuſpended by the increaſed energy of the mind and body, but it ſeems that its very powers of retention are either weakened or loſt by the ſympathy which it poſſeſſes with the mind through the medium of the organs of ſenſe. I witneſſed this lately upon a very grand and extended ſcale, in which I was a fellow ſufferer. A party of landmen in attempting to ſee the Dutch prizes at the Nore, were overtaken with a ſmart wind and a rough ſea. After having eaten very plentifully, we all continued perfectly well, until one unfortunate gentleman, whoſe ſtomach was more irritable than the reſt, began to diſcharge its contents. The ſympathetic effect was ſoon propagated far and near, and I may ſay with truth, there never exiſted a ſet of more ſickly wretches that ever went on ſhip-board. That this was the conſequence of ſympathy was apparent, from the ſame effect having happened to nearly all from the operation of one and the ſame cauſe. It would however appear, that by habit the ſuſceptible irritability of the ſtomach becomes conſiderably weakened, and its ſtrength greatly increaſed. Hence it was, that the few who had been accúſtomed to the ſea were not only not ſea-ſick, but they felt the ſame craving for food that they had all along manifeſted. Happy men! to be able to reſiſt the cauſes that produce a diſeaſe which enervates the mind and weakens the body more perhaps than any other that can be mentioned; which ſuſpends and paralyſes the courage of the brave, and makes cowards of the timid; that chills the warmth of friendſhip, and ſinks into oblivion the fond parent's care; that renders the miſer forgetful of his wealth, the ſpendthrift of his prodigality. Happy men, I ſay, to have overcome a diſeaſe that renders all who are ſeverely afflicted with it, unmindful whether the veſſel ſinks or ſwims, and indifferent in their choice whether to ſleep or die.

The ſtomach frequently ſympathiſes with the organs of ſenſe, whether it ariſe from diſagreeable flavours impreſſed upon them, or other impreſſions producing nauſea and vomiting. It is not the motion of a ſhip alone, but that of a carriage, of a ſwing, &c. &c. &c. that produce this effect. We know that the modifications of averſion, as fear, anger, ſhame, and grief, inſtantly impair the keenneſs of the appetite, and often occaſion ſickneſs, tremors, fluſhings, weepings, &c.; on the contrary, that the modifications of deſire, as hope, complacence, and joy, improve the appetite, promote digeſtion, and increaſe ſtrength. Such, indeed, is the univerſal ſympathy which the ſtomach poſſeſſes with the ſyſtem in general, that no part of it is affected without the ſtomach being influenced by it. I have known the very idea of taking a vomit of ipecacuanha produce the action of vomiting in a powerful degree. We all know, and too often feel, the violent pain of the head, from the action of indigeſted matter upon the ſtomach. It is therefore neceſſary for me to point out the nature of the nerves, as the agents by which theſe effects are produced, and through which the functions of the ſtomach become ſtrengthened and perfected—weakened or exhauſted.

Of the Nerves of the Stomach, &c.

The ſtomach is ſupplied with nerves from the par vagum and intercoſtal. The par vagum ariſe from the brain, paſs through the baſis of the ſkull along with the internal jugular veins; they are diſtributed to the tongue, œſophagus, larynx, heart, and lungs; and running on each ſide of the œſophagus, may be ſaid to terminate in the ſtomach, liver, and ſemilunar ganglion of the intercoſtals, below the diaphragm, from whence they are again diſtributed to the viſcera of the abdomen. The intercoſtals alſo ariſe from the baſis of the brain, paſs through the baſis of the ſkull along with the carotid arteries. They at firſt run by the fore part of the vertebræ of the neck, ſtill adhering to the coats of thoſe arteries; but having reached the cheſt, they leave theſe arteries, and run before the heads of the ribs, where ſending off branches which paſs between the ribs, they have thence been named intercoſtal. Several of theſe branches uniting form a trunk on each ſide, which running forward towards the middle of the ſpine, perforates the diaphragm, and then terminates in the ſemilunar ganglion of the intercoſtals. Theſe trunks are diſtinguiſhed by the name of the anterior intercoſtals; the original trunks continue their courſe by the ſide of the lumbar vertebræ; after which they run before the ſacrum, and, approaching nearer to each other as they deſcend, terminate before the os coccygis on the ganglion coccygeum impar of Walther. Theſe branches all go to the heart, abdominal viſcera, teſticles in men, and ovaria and uterus in women *.

There have been various experiments made by Dr. Haighton, Mr. Cruickſhank, and others, on the nerves that go to the ſtomach of different dogs. The reſults of theſe experiments evidently ſhew, that not only the action of the ſtomach as a digeſtive organ depends in a great meaſure on the energy of theſe nerves; but that the action of the vital machine becomes ſuſpended and exhauſted, when the connection that ought to exiſt between the organs of ſenſation and conſciouſneſs is cut off, and the organs of vitality, or thoſe that are deſtined to ſupport the functions of the whole.

Exper. 3, by Dr. Haighton. A dog being procured and ſecured, a convenient inciſion was made on the fore part of the neck, and one of the nerves of the eight pair was divided.

---

* I am indebted to Mr. Cruickſhank for this perſpicuous deſcription of theſe nerves, and have followed the order in which he has deſcribed them; although it *perhaps* would have been more correct, had he ſtated that they originate from theſe different viſcera, &c. and finally terminate in the baſis of the ſkull.

He became moroſe, but preſerved his appetite. After a lapſe of three days, the other branch was divided. He immediately became reſtleſs and uneaſy, betraying ſymptoms of great diſtreſs upon the ſtomach, with palpitation and tremor, until the fourth day, when he died.

Exper. 1. Another dog was procured: inſtead of the nerves being divided ſeparately, they were cut off at once, and the utmoſt ſymptoms of diſtreſs upon the ſtomach came on, which were propagated to the whole frame, and in eight hours he died *.

---

* Theſe experiments, which are detailed in the Philoſophical Tranſactions for 1795, were made with a view of proving that nerves had the power of reproducing themſelves after having been divided, and of recovering the energy which they in conſequence loſt. This Dr. Haighton has proved in a very clear and decided manner. In one experiment, after having divided one of the nerves of the eight pair without much derangement to the ſtomach, he waited the lapſe of nine days, and cut the other. The dog loſt his appetite, and would take milk alone in ſmall quantities, which always produced indigeſtion and great uneaſineſs; he became very much emaciated, and in thirteen days died: that is, he ſurvived twelve days and twelve hours longer than the dog in whom both nerves were cut off at once.

It is impoſſible to behold theſe facts without aſcribing to the nerves a primary office in the functions of ſecretion and of digeſtion, and to deny

In another experiment he waited the lapſe of ſix weeks between the diviſion of the firſt and ſecond branch. The dog bore the diviſion of the firſt very well; but when the ſecond branch was ſeparated, he became evidently diſordered, but far leſs in degree than in the former caſe. He refuſed ſolid food, but took milk, and the actions of the ſtomach were for a long time conſiderably impaired, and conſtantly haraſſed with ſymptoms of indigeſtion. It was more than one month from the ſecond operation, before he could eat food of a ſolid kind. Inſtead of dying, as the former dog, in ſix months, he recovered his health. The animal was kept nineteen months, during which period he faithfully performed the important office of a watch-dog.

It was not the functions of the ſtomach alone that returned; but the recurrent branch of the eight pair which are the true vocal nerves having been cut through, he conſequently loſt his voice; but in proportion as his general health improved, his voice returned, and in ſix months time he could bark as ſtrongly as before, and the pitch of his voice was conſiderably raiſed. The cauſe of this recovery would therefore ſeem, prima facie, to have ariſen from the divided nerve having been reproduced, and the action which it had loſt, conſequently recovered through the medium that was formed. I ſay, prima facie proved by the ſtomach having recovered its functions. It was further proved negatively alſo.

The

deny that it is through them that a ſympathetic connection is preſerved between the ſtomach and the brain,—between the different prepara-

---

The dog upon which the ſecond pair of nerves had been divided, nineteen months after the firſt, being ſtill in Dr. Haighton's poſſeſſion, he cut through them both in immediate ſucceſſion. The uſual ſymptoms were immediately produced, and continued until the ſecond day, when the dog died. On examining after death the fabric of the new ſubſtance, it appeared to be of a harder quality than the original nerves, ſomewhat ſimilar to a ganglion, and conſiderably thicker than the branches between which it was interpoſed.

This re-union of the nerves was obſerved alſo by Mr. Cruickſhank in ſome experiments which he performed upon the par vagum and intercoſtal. The dog ſurvived the diviſion of one branch, but died on the ſeventh day after the ſecond had been cut through. The nerves which had been firſt divided, and which ſeparation had only happened ſeventeen days (from January 25, 1776, to February 10), appeared, ſays Mr. Cruickſhank, united by a ſubſtance of the ſame colour as the nerve, but not fibrous; and the extremities formed by the diviſion were ſtill diſtinguiſhed by ſwellings rounded in form of ganglions. The ſame appearance had taken place with reſpect to the nerves of the left ſide (of thoſe that had been divided ten days only before the animal's death), though the divided extremities ſeemed to have been full two inches apart; the uniting ſubſtance was more bloody than that of the other ſide.

tory organs we have already deſcribed, and thoſe that are deſtined to complete the digeſtive proceſs.

It is probable that in vegetables and in the loweſt order of animals, the quantity of food they receive correſponds to the wants and waſte of their reſpective ſyſtems, and to the power of the organs by which that food is aſſimilated. On the contrary, in the higher order of brutes, and eſpecially of man when he acts like a brute, ſuch is the appetite they poſſeſs, that they are frequently led to take not only ſubſtances that are totally unapt and unfit to be acted upon or digeſted, but to devour a much larger quantity than is either neceſſary for the ſupport of the ſyſtem, or than the limited power of the digeſtive organs can aſſimilate. A neceſſity evidently appears for the exiſtence of auxiliary organs, with a view of affording to the ſtomach a larger quantity of blood for the formation of gaſtric juice; and finally, as the means of ſeparating the digeſted from the undigeſted parts of the aliment, the chylous from the fæculent. If the whole of the food which the ſtomach receives were perfectly aſſimilated, and chyle ſubſiſted in the ſtomach purely and individually, abſorption might take place from the ſtomach immediately, and there would be no neceſſity for the exiſtence of the inteſtinal canal. Since however it is a fact that chyme does exiſt in the ſtomach, fæculent matter with chylous, undigeſted with digeſted, the neceſſity muſt evidently appear for the exiſtence not only of the inteſtinal canal, but of particular organs that produce particular fluids, that poſſeſs the power of producing ſeparation between both, ſo that the pure chyle may be immediately applied to the ſurface of the inteſtinal canal, and be abſorbed by the lacteal veſſels, and the fæculent parts expelled out of the ſyſtem as excrementitious and foreign. The whole forms one maſs of a pappy or pultaceous conſiſtence, of a greyiſh colour, ſtreaked with a white fluid, and is called *chyme*. *Chyme* therefore conſiſts of chyle or aliment digeſted with food imperfectly aſſimilated, or which is totally unaltered. The whole is progreſſively propelled, by the muſcular coat of the ſtomach, through the pyloric extremity of that organ, into the duodenum. I am therefore led to enquire into the fabric of the inteſtinal canal, as the part in which thoſe acts of ſeparation take place; of the pancreas and liver, as the organs that are eſpecially deſtined to prepare particular fluids, by means of which the fæculent parts of the food are ſeparated from the chylous; and finally, of the ſpleen, by which thoſe different organs are ſupplied with a more abundant quantity of blood, when their actions are præternaturally excited.

CHAP. X.

OF THE PANCREAS.

Its ſituation—how ſupplied with blood—its fabric deſcribed—proved to be a ſecretory organ—this ſecretory power ſometimes paſſive—ſometimes active—when active it forms the pancreatic juice—its ſenſible quality aſcertained by analyſis—how and where conveyed—its uſe.

THE pancreas is ſituated tranſverſely acroſs the ſpine, extending from the ſpleen to the left as far as the right curvature of the ſtomach, and lies immediately under that organ. It is principally ſupplied with blood, as I before obſerved, through the medium of ramifications from the ſplenic trunk, not from this ſource alone. The right portion of the pancreas receives ramifications from the ſuperior meſenteric, and right gaſtric epiploic arteries alſo. Theſe veſſels, after entering the fabric of this organ, have two modes of termination into an exhalant outlet, and a returning vein: into an exhalant outlet, not only for the purpoſe of affording it nouriſhment, but with a view to its ſecretory office.

The ſeat in which this ſecretory power reſides, appears to be in a number of ſmall cells with which the pancreas abounds. It would ſeem that the ſpecific power of the pancreas, like that of the ſalivary glands, is ſometimes in a dormant, ſometimes in an active ſtate. The neceſſity which ſubſiſts for the action of theſe parts, depends on the ſympathetic influence they receive from the organs to which they are deſtined to afford aſſiſtance. The action of the ſalivary glands we have ſeen was excited either by appetite, or more eſpecially by the proceſs of manducation. The action of the pancreas is excited by the ſympathetic influence it receives, either from the ſtomach or duodenum, or both. That the ſtomach has an effect upon the pancreas is probable from hence, that in the fœtal ſtate, when the ſtomach is paſſive, the ſpecific power of the pancreas is in a dormant condition. On the contrary, in the adult, when the aſſimilation and comminution of the food take place in the ſtomach, the ſpecific power of the pancreas is excited. and a fluid which has derived its appellation from the name of the organ itſelf is ſecreted, called *pancreatic juice.*

The *pancreatic juice* is received by a number of ſmall ducts, which ariſe from the cells in which this fluid is formed; theſe ducts gradually and progreſſively unite, forming one common trunk, which running along the middle of the pancreas, pierces the coats of the duodenum; and finally diſcharges its contents upon the ſurface of that organ, about two inches from its origin.

An eſtimation of the quantity of pancreatic juice which the pancreas ſecretes has been attempted, not poſitively but relatively, not from the quantity of juice collected, but from the proportion which the gland bears to the magnitude of the parotid and the other ſalivary glands. The whole ſalivary glands collected do not weigh more than two ounces. On the contrary, the pancreas weighs almoſt five. We may therefore conclude, that the proportion of this fluid produced is far greater than of ſaliva. But as we are ignorant how much ſaliva the ſalivary glands ſecrete, we muſt conſequently continue ignorant of the quantity of juice which the pancreas produces.

Although the quantity has not been aſcertained, an attempt has been made to inveſtigate its qualities; it has been collected by De Graaf, and Profeſſor Schuylius, of Leyden, by tying a quill to the pancreatic duct of a dog. The internal part became conſequently filled with it. Accordingly the gentlemen found that it was either acid or alcaleſcent, or both. How could it be otherwiſe? How could a mode ſo unnatural and uncertain produce any but a morbid ſecretion? And how could a morbid ſecretion, thus excited and continued for ſeveral hours, produce any other fluid than one poſſeſſing ſenſible and chemical qualities? It is an alteration which the ſaliva ſuſtains from the mere effect of colds, which the tears perpetually undergo, from the impreſſion which the lachrymal glands ſuffer, either from affections of the mind—from diſeaſe, or from other irritating cauſes. In their natural ſtate the tears are inſipid and neutral; in their morbid ſtate they are pungent and ſaline, active and corroding. It cannot be otherwiſe, becauſe the morbid is the very negative of the healthy ſtate; and there cannot be a greater proof of the bland, mild, inodorous, inſipid nature of the ſaliva, of the tears, and of the pancreatic juice, when they ſubſiſt in the healthy ſtate, than the ſenſible and chemical properties they poſſeſs in a ſtate of diſeaſe produced by means ſo cruel and abſurd. It has been collected and taſted. It has been collected and decompoſed. The cryſtals depoſited after evaporation were of a cubic and ſpiculated form; the former like thoſe of common ſalt; the latter like thoſe we ſee from the cryſtallization of ſal ammoniac: and as luna cornea is formed by the addition of nitrated ſilver, it is probable that the marine acid is in union with the alcaline parts. But why ſhould we take its morbid and decompoſed ſtate as the ſtandard of its perfection, and the ſenſible properties it then obtains as the mode of its operation; when we know that in its pure and healthy ſtate it is deſtitute of thoſe qualities, and conſequently that it is not by virtue of their power that its operation depends? To me it appears far more reaſonable to conclude, that the pancreatic fluid acts not by a chemical, but by a living power, ſimilar to what we have ſeen the gaſtric juice ſo eminently diſplay; and that it co-operates in perfecting what the other was unable to complete. It tends to ſeparate the chylous part of the chyme from the fæculent, that the one may be immediately applied to the ſurface of the inteſtines for the lacteals to abſorb, and that the latter may be ſeparated and expelled.

As the pancreatic juice performs a joint and co-operative office with the bile in the proceſs of chylification, I think it will be better to ſuſpend any further obſervation upon the ſubject until the nature of the hepatic ſyſtem has been aſcertained.

CHAP. XI.

OF THE SPLEEN.

It is ſupplied with a large quantity of blood—it is deſtitute of an excretory outlet, and therefore does not appear to perform a ſecretory office—it does not ſeem to be an eſſential, but an auxiliary organ, deſtined to ſupply with blood the ſtomach and pancreas upon extraordinary occaſions—experiments made by Dr. Haighton prove this to be its uſe—the qualities of the blood examined—conveyed by the ſplenic artery and returned by the ſplenic veins.

WHEN we reflect on the increaſed actions which the digeſtive and aſſimilating organs are deſtined to perform in conſequence of the different kinds and quantities of bodies on which they are to act, a neceſſity will be apparent that organs of an auxiliary nature ſhould exiſt, with a view of furniſhing an additional quantity of blood, at thoſe times that ſuch a ſupply becomes neceſſary.

That an additional quantity of blood is determined to particular glands when their ſpecific

cific action is excited, is proved from the effects which we behold every gland diſplay. All have a regular and conſtant ſupply for their nouriſhment and ſupport: there is, however, an extraordinary and occaſional increaſe when the ſpecific powers they poſſeſs are excited into action. The fact is proved by the increaſed flow of tears from the lachrymal, and of ſaliva from the ſalivary glands. We may conſequently preſume that the ſtomach and pancreas receive an additional ſupply alſo when the introduction of food into the ſtomach, or of chyme into the duodenum, calls for the extraordinary exertion of theſe organs. Theſe different glandular bodies have all an excretory duct, which immediately conveys the fluid they ſecrete. With the ſpleen it is far otherwiſe. Although its internal ſtructure is apparently ſpongy and cellular, like other glands, it differs, however, from them, in being deſtitute of any excretory outlet whatever. For what purpoſe then is this organ eſpecially deſigned, and what function is it intended to perform? It does not appear to be an eſſential, but an auxiliary organ only —not an eſſential one, becauſe different animals,

mals, both men and brutes, are frequently deſtitute of a ſpleen; and brutes for the ſake of experiment have been deprived of it, without the ſyſtem having ſuſtained in conſequence any particular derangement.

Exper. The ſpleen of a dog was removed, and in a few days the wound healed. He was kept ſeveral weeks after the operation, during which time he ran about the houſe as any other dog would have done.

Seeing then that we are not to conſider the ſpleen either as a ſecretory organ, or as an organ eſſential to the preſervation of the functions of the ſyſtem; I am naturally led to conclude, that it is of an auxiliary and ſubordinate nature, deſtined to afford aſſiſtance only to thoſe organs with which it is connected, and by the locality of whoſe ſituation it can be affected.

The ſpleen is ſituated on the left ſide of the abdomen, varying in ſhape in different animals, according to the fabric of their trunk. It is by the enlargement which the ſtomach ſuſtains, and the increaſed ſpace which it conſequently occupies after a full meal, when it is diſtended with a large quantity of food, that the left or great curvature becomes approximated to the ſpleen, and a conſiderable degree of compreſſion upon it is produced; although it is too remote to produce ſuch an effect when it is empty. The queſtion therefore preſents itſelf, what will thoſe unequal conſequences produce, of preſſure in the one caſe, and perfect freedom in the other? It will, I believe, be readily granted, that preſſure upon the ſpleen muſt eventually tend to diminiſh the capacity of the veſſels with which it is ſupplied, and which are deſtined to convey a quantity of blood through its ſubſtance. The diminution therefore of the ramification of the ſplenic arteries muſt neceſſarily produce an accumulation in the ſplenic trunks. The blood conſequently flows into other channels, through which it can obtain admiſſion. Theſe channels conſiſt in the large branches which the ſplenic trunk gives out to the ſtomach, called gaſtrica ſiniſtra, through the five ſmaller ramifications called vaſa brevia; and finally, through the ſeveral branches which the ſplenic artery diſtributes to the pancreas.

The increaſed quantity of blood which theſe organs in conſequence receive, enables them to ſecrete a larger proportion of the gaſtric and pancreatic juice, at a time when the diſtenſion which the ſtomach ſuſtains from the plenitude of food renders the ſupply of gaſtric juice more eſſentially neceſſary, or when the accumulation of chyme in the duodenum demands a more abundant quantity of pancreatic.

I had long thought that the ſpleen was deſtined to be an auxiliary organ to the digeſtive and chylopoetic ſyſtem, becauſe I ſaw the neceſſity that they ſhould be ſupplied with extraordinary means, when their actions were particularly called forth. I feel myſelf indebted and obliged to Dr. Haighton for ſome experiments which he has performed, which go to prove that the preſſure which the ſpleen is made artificially to undergo, not only prevents the paſſage of the blood through that organ, but that it does actually produce an increaſed accumulation in the veſſels with which the ſtomach and pancreas are ſupplied. I ſhall forbear giving in detail the experiments which he has made, as I know that he means to proſecute the inveſtigation of the ſubject; and I hope that he will impart to the public the phenomena he has beheld. I ſhall merely ſtate, that he opened the abdomen of a living dog; drew out the ſpleen in ſuch a manner that he could behold the ſurrounding veſſels, and that he ſaw the paſſage of the blood through the ſplenic veins in conſequence retarded, and an accumulation take place in the veſſels that led to the ſtomach and pancreas.

That this is the uſe of the ſpleen, is rendered farther probable from the nature of its ſtructure alone; for, ſince it does not perform a ſecretory office, to what other purpoſe can it be deſigned? It appears that various experiments have been made upon blood conveyed to the ſpleen and returned from it; and although it is true that there was ſome variety in the colour, the relative proportion which the ſerum bore to the craſſamentum, and the preſervative properties contained by the blood conveyed by the artery and returned by the veins, were apparently the ſame*.

The abdomen of a living dog being opened, the ſpleen with the veſſels being gently drawn out, blood was taken both from the artery and vein, and received in two cups equal and ſimilar in ſize and ſhape. Both coagulated in leſs than two minutes, and ſeparated afterwards into ſerum and craſſamentum. In twenty-four hours the ſerum of both was accurately weighed; and the ſerum from the vein was exactly the ſame in quantity as the ſerum from the artery.

---

* Vide Dr. Saunders's Treatiſe on the Economy and Functions of the Liver.

Not the quantity of ſerum alone was the ſame in the vein as in the artery, but the quality alſo. Equal portions of each ſerum were expoſed nearly to the ſame degree of heat until coagulation had taken place: upon preſſing the ſurface of each, there exuded at different points ſmall particles of a watery fluid called by Senac the ſeroſity of the blood. On examining the proportion of each, no difference could be found. And finally, that this blood contained by the ſplenic vein contained preſervative properties, as well as the blood contained by the ſplenic artery, was proved by expoſing both for four hours to a heat of 90 degrees; but neither of them betrayed the ſmalleſt ſigns of putrefaction. Thus it would ſeem, that the ſpleen performs no glandular office.

CHAP. XII.

ON THE HEPATIC SYSTEM.

The ſtructure of the liver—its evolution more active in the fœtal than in the adult ſtate—has a large quantity of blood diſtributed to it—but its ſecretory office dormant – in the adult ſtate it is ſupplied with venal blood for its ſecretory office, and with arterial for its ſupport—its ſecretory office exerted, and bile formed—the cauſe of this difference in the formation of bile—proceeds from the liver ſympathiſing with the ſtomach—of the vena portæ, how it ariſes—how it terminates into pori biliarii, and the blood then converted into bile—the nature of hepatic bile—of cyſtic—its decompoſition, &c. the mode of its operation examined and proved—the primary and the ſecondary uſe of bile—of hepatic and cyſtic.

THE liver itſelf is ſituated on the right ſide, immediately beneath the diaphragm, and is of a brown or chocolate colour. It is generally divided into two partitions or lobes: the largeſt one of the two is ſituated on the right hypochondrium;

chondrium; the ſmaller is placed in the left portion of the liver, and extends acroſs the epigaſtric region to the left. The liver is thick at top and thin at bottom; convex at its fore and concave at its poſterior part. It is ſupported and maintained in its ſituation by the medium of different ligaments, and of different veſſels.

The evolution which the liver undergoes in the fœtal ſtate, ſeems to be more rapid than the evolution of any other gland in the ſyſtem. During the nine months of geſtation, it appears to have attained more than one third of the growth which it is ultimately deſtined to aſſume. In the fœtal ſtate, it not only receives blood from the chylopoetic organs; but it is eſpecially ſupplied with a large proportion from the placenta, through the medium of the umbilical vein. This large quantity of blood which the fœtal liver receives appears to be ſubſervient to the proceſs of evolution alone. For, during the whole nine months of geſtation, the proportion of bile produced is in quantity very ſmall; in quality very mild and bland, harmonizing with the ſurface of the inteſtines in ſuch a manner, that it does not ſtimulate their coats, and is conſequently retained: if it were acrid and purgative, it would be expelled as deleterious and foreign.

Far different is the condition of the liver in the adult, from what we have beheld it to be in the fœtal ſtate, although it is then deprived of the large proportion of blood from the umbilical veins, which it uſed to receive.

Inſtead of being nouriſhed with blood from the umbilical veins and hepatic artery together, a marked and an evident alteration takes place: it is deprived of the blood from the umbilical veins, and becomes ſupplied by means of the hepatic artery alone, for the purpoſe of its evolution and ſupport in general, whilſt the vena portarum conveys blood for its ſecretory office in particular.

The queſtion here naturally preſents itſelf: How comes it to paſs, that there ſubſiſts ſo ſtriking a difference in the actions of the liver at different times? Whilſt in the fœtal ſtate it is ſupplied with a more abundant quantity of blood than in the adult, that its ſecretory office is leſs active? And on the contrary, in the adult, when the ſupply of blood it receives is comparatively ſmaller, that it diſplays its ſecretory power in a more active degree? The cauſe of this difference is evidently to be ſought in the reſpective condition of the fœtal and adult ſtates, and the reſpective modes of their ſubſiſtence. In the fœtal ſtate, the nouriſhment it receives comes directly from the mother, without the intervention of its own aſſimilating organs; their ſecretory office is in a paſſive ſtate, in order that their evolution may be more rapid. On the contrary, in the adult ſtate, it is by the operation of the aſſimilating organs alone, that nouriſhment is converted and aſſimilated, and that the chylopoetic organs have their ſpecific powers called forth, and conſequently perform the office for which they are eſpecially deſigned.

In order that the liver ſhould be able to perform theſe ſeparate and diſtinct functions—of evolution and of ſecretion—it ſeems neceſſary that it ſhould be ſupplied with blood of a diſtinct and different kind. The blood which the liver receives for its evolution and ſupport in the fœtal and adult ſtates, either from the umbilical vein or hepatic artery, is analogous to arterial blood; to that blood which poſſeſſes living and preſervative properties in the higheſt and moſt exalted degree; which retains in the moſt eminent manner the aptitude to be acted upon by the principle of life for the purpoſe of evolution and of organization, and which is univerſally employed for that end.

On the contrary, the blood which the different ſecretory organs receive for their ſecretory office, ſeems differently modified in every particular organ. I do not mean to ſay, that the ſtreams of blood that flow from the ſame fountain in their aggregate qualities are different. I mean, that thoſe qualities are particularly modified and accommodated to the nature of the organ which it is deſtined to ſupply, by the terminated extremity of the veſſels by which it is conveyed. This is eſpecially the caſe in the veſſels which convey blood to the brain—the ſame with the teſtis, and in ſhort with every other organ. It would ſeem to be eſpecially the caſe with the liver itſelf; ſo that the arterial blood which it receives, either through the umbilical vein or hepatic artery, poſſeſſes the aptitude to be acted upon by the living principle, and anſwers the purpoſe of evolution, but does not anſwer its ſecretory office. On the contrary, the blood which the vena portæ conveys, and which is venous blood, ſtrictly ſo called, ſeems eſpecially fitted to anſwer the ſecretory functions of the liver. It is then that this power is called forth, when blood is conveyed to the organ in which it reſides, fitted and adapted for that purpoſe. It is therefore neceſſary that I ſhould point out the ſources from whence this blood is eſpecially obtained.*.

---

* I was lately favoured by Mr. Cook, a reſpectable ſurgeon of Barking in Eſſex, with an account of a very extraordinary diſeaſe of the liver, and which he had examined a few days before. It was the caſe of a lady, who for four or five years preceding her death complained of pain in the left ſide, which extended a conſiderable way acroſs to the right. Below the edge of the ribs there was at times diſtinctly to be felt a hard tumour, painful to the touch. She was occaſionally afflicted with a ſhortneſs of breath, and a troubleſome cough. She was able to lie on the right ſide, but with great difficulty on the left. Haraſſed and oppreſſed with the continuation of theſe ſymptoms, ſhe died, and her body was opened. The liver was found enlarged to an enormous ſize; having within two diſtinct and ſeparate cyſtes, evidently containing a fluid. On the ſuperior part of the left lobe of the liver, there was a cyſt that contained two pints of clear limpid

Of the Vena Portæ.

The blood which was conveyed to the different organs I have deſcribed, and which was not employed for their ſecretory office, is received by continuous veins—from the ſtomach by the cæliac vein; from the ſpleen by the ſplenic; from the inteſtinal canal by the ſuperior and inferior meſenteric; and finally from the pancreas by the vein of that appellation. Theſe various veſſels, which receive from theſe organs the reſiduary part of the blood, gradually unite and congregate into one trunk, forming the *vena portarum*. It obtains the appellation of porta, from the part of the liver through which it enters. The quality of its fabric differs materially from the fabric

---

ſerum, having rather a yellow caſt. The other cyſt was ſituated cloſe to the lower rib on the right ſide, the projecting point of which could be felt whilſt the patient was alive, and contained two pints of water alſo. The inveſting membrane was of the colour and conſiſtency of leather. The other portions of the liver were apparently in an healthy ſtate. The gall bladder was diſtended and full of bile. The heart was ſurrounded with fat. The lungs were compreſſed, and occupied a very ſmall ſpace, but without apparent diſeaſe. There was about an ounce of ſerum in the thorax.

we have ſeen arteries poſſeſs; although it is analogous to them in the uſe for which it is deſigned.

It differs from arteries in its fabric, in having no muſcular coat, and a leſs elaſtic ligament. It differs from them alſo in the quality of the blood it receives and conveys. Although the vena portæ differs from an artery in theſe particulars, it reſembles them in being deſtitute of valves, and in the mode of its termination. The vena portæ, after having been formed by the congregation of different veins of the chylopoetic viſcera, enters the liver, and has this trunk ſegregated into branches from a centre to a circumference, terminating in the ſubſtance of the liver itſelf, like an artery, into exhalant outlets and returning veins.

Thus then it appears that the quantity of blood which the vena portæ receives muſt entirely depend on the quantity which the different arteries ſubſervient to the chylopoetic organs convey, proving in a very decided manner, that the fluid (bile) into which the blood is changed by the powers of the liver, is wholly ſubſervient and ſubordinate to their uſe. Not ſubſervient to their uſe alone, but it evidently appears that the ſpecific (ſecretory) power of the liver is excited by the ſympathy it receives from the ſtomach and inteſtines:—when they are dormant, it is paſſive; when they are active, its action is excited, and the blood it receives is converted into bile. That this is a fact, I ſay, is proved from the increaſed quantity of bile which is produced in the adult from what there is in the fœtal ſtate.

So that in point of quantity and quality, in point of time and place, the liver is ſupplied with blood for its ſecretory office in proportion as the fluid is wanted which in conſequence is produced by it. The exhalant termination of the hepatic artery differs from the exhalant outlet of the vena portæ. Whilſt the former depoſits its contents in the ſubſtance of the liver itſelf for its nouriſhment and ſupport, the exhalant outlet of the latter terminates into the *pori biliarii* for the formation of bile; ſo that the pori biliarii have their origin where the exhalant outlets of the vena portæ have their termination*.

---

* It appears to me extremely improper to apply the term

From the pori biliarii, branches ariſe which gradually unite and ultimately form the *truncus hepaticus.* The truncus hepaticus therefore is formed from the aggregate of the ducti biliarii. After quitting the liver, and reaching the incurvation of the duodenum, it perforates directly its external coat, and indirectly its internal, running a ſhort diſtance within the ſubſtance of the inteſtine itſelf, before its extremity opens on the internal ſurface of it. When the liver therefore ſecretes bile, and the periſtaltic motion of the inteſtine is ſuſpended, an accumulation in the hepatic trunk, and perhaps a regurgitation into the pori biliarii, and branches of the vena portæ, would frequently take place, if it were not for the communication with the gall-bladder through the medium of the ductus cyſticus.

The ductus cyſticus has its origin about two

---

term *pores* to canals of conſiderable length. I however wiſh to have it underſtood, that I mean to retain the old muſty term of *pore*, confining it however to the cell or convolution (be it what it may) in which bile is formed. The hepatic branches or excretory ducts that ariſe from theſe *pores* I call *rami biliarii.* And finally, theſe branches or rami biliarii, when united in one trunk, I call *truncus hepaticus.* I retain the old term of *ductus cyſticus*, as being applicable to the uſe which it performs.

inches from the termination of the truncus hepaticus into the duodenum : after paſſing obliquely upwards, it terminates in the gall-bladder.

The gall-bladder is of a pyriform figure, ſituated in a depreſſion of the concave ſurface of the right lobe of the liver, to which it is attached by a duplicature of the peritonæum : it is properly ſupplied with blood-veſſels, nerves, and abſorbents, and ſecretes from its internal ſurface a fluid of a mucous appearance.

Since then it appears that the communication between the liver and duodenum, through the truncus hepaticus, is more direct than through the ductus cyſticus, we may conclude that the regular courſe of the bile from the liver to the duodenum is through the hepatic trunk. We may conſequently infer that its paſſage through the cyſtic duct into the gall-bladder, is rather to prevent regurgitation of bile from the hepatic trunk, when the liver ſecretes more bile than the ductus communis can convey, or when the duodenum is in a paſſive ſtate. The gall-bladder therefore would ſeem to be deſtined not ſo much to do good, as to prevent miſchief; not ſo much to furniſh a regular ſupply of bile to the inteſtines, as to prevent regurgitation into the liver.

Bile is not only of no uſe either in the pori biliarii or gall-bladder, but produces frequently in them very deleterious effects. It is of uſe only in the inteſtinal canal: and whenever it acts as bile is intended to do, it muſt return from the gall-bladder back into the inteſtines.

Admitting then that bile is deſtined to perform ſome office in the part where it is immediately conveyed by the excretory ducts of the organ by which it is produced; it is legitimate, I ſay, to ſearch for its properties and uſe, in thoſe ſituations where its paſſage is direct and almoſt conſtant, rather than in thoſe where it is indirect and precarious; and as the paſſage of the bile from the liver through the truncus hepaticus into the duodenum is direct, and, on the contrary, the paſſage of the bile from the liver to the hepatic trunk, and from the hepatic trunk into the cyſtic duct and the gall-bladder, is circuitous; it is moſt obvious that the gall-bladder is not to be conſidered either as an organ eſſential to the inteſtines for the production of bile, or the bile it contains ſo pure in its quality, as that which flows immediately from the liver into the hepatic duct. If we therefore combine the anatomical ſtructure of the hepatic ſyſtem with the uſe of the fluid it prepares and conveys, we ſhall be led directly to conclude that hepatic bile is the beſt, and cyſtic bile is the worſt; and that hepatic bile is the ſtandard by which the property of cyſtic bile is to be meaſured.

Of Hepatic Bile.

Having aſcertained that bile is formed from venous blood, by the living powers of the liver, it is here neceſſary to inveſtigate the properties it ſeems to poſſeſs with relation to the uſe for which it is deſigned.

It may be conſidered as a fact univerſally true, that arterial blood poſſeſſes an higher degree of vital energy than venal: it is arterial blood that is conveyed to the different parts of the ſyſtem, for their nouriſhment and ſupport, and it is venous blood only that returns the reſiduum. Since therefore bile is formed from venal blood, it is a natural conſequence that the fluid produced from it, ſhould poſſeſs leſs living power than that which is formed from arterial blood: we may therefore preſume, that bile poſſeſſes a leſs degree of living power, than either the gaſtric or pancreatic juice, the produce of arterial blood. Although bile poſſeſſes a leſs degree of life than either of theſe fluids, it ſeems however to contain conſiderable living properties.

Exper. Equal quantities of blood and bile of the ſame ox, were each put into different veſſels of the ſame ſize, and expoſed to the ſame degree of heat: on the third day the blood began to give out by its odour marks of putrefaction; the bile remained in its natural ſtate; on the fourth day the bile had a pungent odour, by no means ungrateful, whilſt the blood was extremely putrid: on the ſixth day the bile became putrid, and had a very offenſive ſmell. Since therefore bile was freſh at firſt, but became afterwards putrid by expoſure to the air, and by departing from the organ by which it was formed, it is very evident that its ſweetneſs aroſe from the living power it contained, and that it was owing to a deprivation of that living power, that it became decompoſed by the external ſubſtances to which it was expoſed, and that it conſequently was reſolved into its conſtituent parts. It is by virtue of this living power that the various component parts of which the different ſolids and fluids of the ſyſtem conſiſt become united in one whole, and that the parts are apparently of an homogeneous nature. It is by the deprivation of the living principle that the different parts continually ſuſtain, that their bond of continuity becomes perpetually weakened and ultimately loſt, and a decompoſition into their ſenſible and common properties immediately enſues. It may therefore be laid down as a law, that the parts which poſſeſs the higheſt degree of life retain the leaſt ſenſible properties; and on the contrary, the parts that retain the moſt ſenſible properties, poſſeſs the leaſt vital energy. That this is a fact generally true, is proved by comparing the incretions with the excretion, the chyle with the fæces, the ſerum with the tears, with the urine or matter of perſpiration: it may be extended to the bile itſelf, not only with relation either to the gaſtric or pancreatic juice, but to hepatic and cyſtic bile alſo.

Hepatic bile, either in the pori biliarii or truncus hepaticus, is a thin fluid, of a yellow colour, ſomewhat bitter to the taſte; almoſt inodorous to the olfactory ſenſe, poſſeſſing living properties for a conſiderable time after ſecretion, undergoing certain changes by reſidence, and ultimately becoming decompoſed into its conſtituent parts.

That it poſſeſſes conſiderable living powers is abundantly proved by putting its preſervative properties to the teſt with thoſe of blood; that it is not very viſcid, is proved by its appearance either in the pori biliarii or hepatic trunk; and that it is not very bitter, is alſo proved by the taſte of the liver itſelf. If it be eaten freſh it is ſweetiſh, but becomes very bitter if kept for ſome time. Theſe are the general properties of hepatic bile; of that bile which is generally paſſing from the liver into the duodenum. The want of ſenſible properties in hepatic bile, and the preſence of living, is a proof that it acts, when it reaches its ſeat in the duodenum, by a living and not by a chemical power; it is there conveyed by the excretory duct of the liver, when the periſtaltic motion of the inteſtine enables its internal coat to open and allow the admiſſion of bile upon its ſurface.

After bile has been ſecreted by the liver, although conveyed by the hepatic trunk, if it cannot obtain admiſſion into the duodenum, it flows back into the cyſtic duct, and is from thence conveyed into the gall-bladder. So that the bile that is contained by the gall-bladder is the ſame bile that would have flowed into the duodenum if it had been in an active, inſtead of a paſſive ſtate. It is therefore neceſſary to examine the properties of cyſtic bile with relation to hepatic; and the changes it has undergone in conſequence of its reſidence in a receptacle apparently paſſive for a conſiderable time after ſecretion.

Of Cyſtic Bile.

That the gall-bladder is ſupplied with the bile it contains, from the liver itſelf, through the medium of the hepatic and cyſtic ducts, is a fact as univerſally admitted as its power is denied of ſecreting the bile it is found to contain; ſo that if the hepatic and cyſtic ducts were completely obſtructed, the gall-bladder would be perpetually empty of bilious matter. Admitting then, that it is merely the recipient of bile when either the liver ſecretes more than the hepatic duct can convey, or (what is more uſually the caſe) when the liver continues

tinues to ſecrete bile at thoſe times that the duodenum is in a paſſive ſtate; we muſt conclude that it then obtains a paſſage through the cyſtic duct into the bladder. When hepatic bile gets into the gall-bladder, it certainly acquires properties very different from thoſe it before poſſeſſed either in the pori biliarii or hepatic trunk: inſtead of being a thin, yellow, ſweetiſh, inodorous, and apparently homogeneous fluid—cyſtic bile by long reſidence becomes of a green, and even of a black colour, intenſely bitter to the taſte, offenſive to the ſmell, apparently heterogeneous in its compoſition, of a very viſcid conſiſtence, frequently coagulating, ſometimes concreting and forming calculi. The queſtion then is, whether the ſenſible properties of cyſtic bile above enumerated, ariſe from any addition it receives from the gall-bladder, or whether they do not proceed from a privation of its living principle, the loſs of which makes the whole to be decompoſed into its conſtituent parts.

The changes the bile undergoes in the gall-bladder by the living power of the ſyſtem, conſiſt in the addition it receives either from a quantity of mucus which is continually ſecreted from its internal ſurface, or by the loſs it ſuſtains in conſequence of the action of the abſorbents with which the gall-bladder is ſupplied. The addition of the mucus alone cannot be the immediate cauſe of the ſenſible properties cyſtic bile ultimately aſſumes, becauſe mucus for ſome time after ſecretion ſeems almoſt deſtitute of any; neither does there appear to me ſufficient evidence that the abſorbent veſſels take up the moſt aqueous parts only, and leave behind the thickeſt proportion as the reſiduum of the whole. It ſeems more probable that the ſenſible properties cyſtic bile ultimately aſſumes, ariſe from a deprivation of its preſervative power, by which it begins to loſe the identity of its own nature, and undergoes nearly the ſame changes by reſidence in the gall-bladder that it would have done out of the living ſyſtem. Theſe changes proceed from the operation of a law by which the different parts of the ſyſtem are governed, and by which the connection of the ſecreted fluids with the organs by which they are produced is regulated.

It is a law univerſally true, that the further effects depart from their cauſes, the power of retaining their own qualities is proportionably weakened and diminiſhed.

Since then the gall-bladder is the part of the whole hepatic ſyſtem moſt remote from the liver (the cauſe and ſource of biliary ſecretion), every inſtant of time bile remains in the gall-bladder, it is conſtantly changing from a better to a worſe condition—from a living to a dying ſtate.

It is by the principle of this law that we are to take hepatic bile as the ſtandard by which the quality of cyſtic bile is to be meaſured, and by which we are to conclude that the ſenſible qualities it aſſumes are foreign to the excellence of its nature.

To ſhew the truth of this principle in a ſtronger point of view, I ſhall take up the converſe of this propoſition, and ſhow the abſurdity that would enſue if we were to take cyſtic bile as the teſt by which hepatic bile is to be tried. Inſtead of making every change bile undergoes immediately after ſecretion to be a change from a better to a worſe condition, it would be exactly the oppoſite: it would be a change from worſe to better; and the laſt change into gall-ſtones bile undergoes in the gall-bladder, would be the very beſt change in which it could poſſibly be found.

Since, therefore, hepatic bile is deſtitute of the various properties cyſtic bile poſſeſſes, I am led immediately to conclude that the ſenſible properties of cyſtic bile ariſe from a loſs of that living principle which conſtituted the bond of its elementary parts, by which they become decompoſed and reſolved into a common ſtate. So far therefore from bile poſſeſſing antiſeptic power by virtue of its bitterneſs, the actual preſence of bitterneſs is a teſt by which we are to judge that it is loſing, or is altogether deprived of, moſt of its antiſeptic qualities; and hence it is that gall-ſtones are for the moſt part pungently bitter to the taſte, and that the bitter portion of bile eſpecially reſides in the reſinous part.

Inattention to theſe principles has led my friend Dr. Saunders, a man no leſs amiable in private life than deſervedly eminent in his profeſſion, in his excellent Treatiſe on this ſubject, to draw true concluſions from falſe principles. He has been led, I ſay, to overlook the living power of bile, to examine its ſenſible properties, and to refer the whole of its uſe and action in the living ſyſtem, to their operation; for which purpoſe he eſtabliſhed a number of experiments conducted with the utmoſt ability and preciſion, with a view of aſcertaining the conſtituent parts which entered into the compoſition of bile. The reſult of theſe experiments only proved that cyſtic bile conſiſted of the following ingredients, viz.

1ſt. Of water impregnated with the odorous principle.

2d. Mucilaginous ſubſtance reſembling the albumen ovi.

3d. A reſinous ſubſtance containing the colouring principle and bitter taſte.

4th. The mild mineral alkali.

Theſe experiments only ſhew the component parts of bile, but do not notice the power by which theſe parts were conſtituted and kept in union; they only explain the reſult of the develation and ſeparation of the whole into its conſtituent parts.

That theſe experiments are wholly inſufficient, is further proved from our total incapacity to reproduce bile by ſyntheſis: after the bond of its elementary parts (the living principle) has been deſtroyed by analyſis, we can no more reproduce bile than we can ſugar after it is converted into rum by diſtillation. The reaſon is obvious: both bile and ſugar are ſecreted ſubſtances, the conſequence of a living proceſs; and although we can detect the different parts of which they are compoſed, we cannot by any chemical operation reſtore the living principle by which they are formed, and by which they are preſerved. It is therefore as impoſſible to know the *real* properties of bile by decompoſition, as thoſe of the albumen ovi by coagulation, of ſugar by diſtillation, or of ſerum by putrefaction. Whenever theſe changes have taken place, the original ſubſtance is no more, and the end for which it was originally deſigned can no longer be anſwered. The motion of our fluids might as well be explained upon hydraulic principles, when a living and not a mechanical power is employed, as to aſcribe to ſenſible properties the uſe of parts that depend on living power. For example, in a ſtate of health the ſaliva is a thin colourleſs fluid, inodorous to the ſmell, and inſipid to the taſte; in a high degree of ſcurvy it is ſaline, variouſly coloured, and readily coagulates, forming ſaline cryſtals. In the firſt inſtance it is mild, and in harmony with the ſurrounding parts; in the latter it is acrid and offenſive—excoriates the gums, and produces ulcerations of the mouth. It might as well be argued, that theſe ſenſible properties of ſaliva are eſſential to its action, as that bile acts by virtue of its bitterneſs and colour, by its reſin or its alkali.

The application of heat and of the various menſtrua which were employed to diſcover the properties of bile, would have deſtroyed the living principle of a muſcle, or even of a bone itſelf, and made them ſeparate into their ſeveral parts; much more then would they have the ſame effect when applied to bile. It were abſurd indeed to look for the properties of a muſcle, or of a bone, after mortification had taken place by the operation of fire and faggot, the crucible or the retort; and yet theſe were ſome of the means employed to diſcover the real properties of bile. Chemical experiments therefore made for the purpoſe of inveſtigating the qualities of living matter with a view to its living properties and uſe, are not only *not* ſufficient, but defeat the very aim we have in view; for their operation tends to deſtroy the living power they poſſeſs, and to render their ſenſible properties apparent.

That the living principle has the power of deſtroying the ſenſible properties of common matter, is proved by the operation of the gaſtric juice alone: it is found that ſubſtances of various kinds and poſſeſſing very different properties, when expoſed to its action, are reduced to one ſtandard, and aſſume one quality.

That the ſecretory organs, by virtue of the living principle they poſſeſs, have the ſame power over the blood, is proved by the various ſecretions they produce. Whenever this living principle deſerts the organs, they loſe this power of converſion; and when the blood that circulates through them is not fitted for their purpoſe, it has not the aptitude to be converted by them; and laſtly, when the living principle deſerts both, both become decompoſed; and although in a living ſtate they are apparently very different in their nature, both yield nearly the ſame produce by chemical decompoſition.

Since then we are not to look to the ſenſible properties of bile for its real qualities, it is very evident why the courſe of the hepatic trunk to the duodenum is the moſt direct, and that the gall bladder is an occaſional receptacle only; why the bile it contains is imperfect in its nature ; and therefore why the paſſage of it into the duodenum, inſtead of being regular and direct, is occaſional only and circuitous.

I am therefore led to examine the ſtructure of the parts upon which the bile is diſcharged, with a view to its immediate uſe.

Of the Inteſtinal Canal.

The duodenum conſtitutes the firſt part of the inteſtinal canal, and begins where the pyloric extremity of the ſtomach has its end. Its internal ſurface is at firſt ſmooth and poliſhed. It has ſcarcely proceeded one inch in its courſe when ridges or folds begin evidently to appear, conſtituting valvulæ conniventes. They continue along the remainder of the duodenum and jejunum. They diminiſh in magnitude at the beginning of the ilium, and all traces of them become ſoon after totally obliterated.

Theſe folds are at firſt arranged in a tranſverſe form; they progreſſively loſe their tranſverſe and obtain a more diagonal direction: in the living ſyſtem they are rigid and erect, and not looſe and flaccid, as we behold them in the dead ſubject.

Soon after the valvulæ conniventes terminate, the large inteſtines are ſaid to begin; inſtead of a folded they have a ſmooth and poliſhed ſurface, until their final termination in the extremity of the rectum*.

---

* If the ſurface of the inteſtinal canal be examined, the firſt portion of it is moſt plentifully ſupplied with glandular bodies of a granulated appearance. Theſe glandular bodies aſſume a circumſcribed and follicular ſtructure, eſpecially in the ilium, and are therefore called glandulæ congregatæ. In the large inteſtines they are arranged with more diſtinction, and, from the ſolitary ſtate in which they exiſt, are called glandulæ ſolitariæ. The fluid they ſecrete is apparently of a mucous-like nature, and ſeems deſigned to form a protecting medium between the inteſtines and the chyme, which they receive from the ſtomach, and prevent the fæculent part from being directly and immediately applied to the ſurface of and irritating the inteſtinal canal. It appears to me probable that this conſtitutes the uſe of the mucus which theſe glands ſecrete, although they may be inſtrumental in the proceſs of chylification alſo.

The pancreatic duct either enters ſingly the duodenum, or with the extremity of the ductus communis cholidochus.

When the pancreatic duct enters ſingly, its courſe is more direct than the courſe of the biliary ducts; and when it forms a ductus communis with them, it opens anteriorly to either of them. The ductus communis cholidochus is formed by the union of the hepatic and cyſtic ducts, and enters the internal ſurface of the duodenum in the manner I have before deſcribed.

This peculiarity of conſtruction in the firſt part of the inteſtinal canal, increaſes the extent of its ſurface in a wonderful degree. This increaſe of ſurface ſeems evidently to be deſigned for two reaſons; for the purpoſe of prolonging and retarding the paſſage of the chyme, in this part of its inteſtinal courſe; and to allow a greater ſpace for the exiſtence of lacteal veſſels. The valvulæ conniventes therefore are tranſverſe at firſt, but ſeem gradually to obtain rather a diagonal direction. In the living ſyſtem, as I ſaid before, they are erect and rigid, and not in the flaccid and looſe ſtate, as we behold them in the dead ſubject; ſo that the chyme, inſtead of paſſing over their angles, is involved within their folds. On the contrary, the large inteſtines have a poliſhed ſurface, and have the fibres of their muſcular coat gradually aſſuming a more longitudinal direction in their courſe towards the rectum; ſo that whilſt on the one hand the poliſhed ſurface of the large inteſtines affords no retardation to their contents, the direction of their muſcular fibres on the other hand tends gradually to accelerate its motion towards the rectum; which being placed perpendicularly downward contributes to favour this effect.

The regular periſtaltic motion of the inteſtinal canal is from the ſtomach downwards; and it is always a perverſion of action whenever there is an inverſion of motion;—I do not believe that this regular periſtaltic motion of the inteſtinal canal is governed by the influence of the will more than the action of the heart; I know very well that diarrhœa frequently takes place by paſſions of the mind —but conſtipation alſo frequently happens when the mind wills a diarrhœa. It therefore appears to me an inſtinctive act like that of ſleep, which is always interrupted by the energy of the mind; it goes on more perfectly during ſleep than awake, and is more irregular in thoſe of a contemplative diſpoſition than in thoſe who live a mere animal life.

The extremity of the canal, indeed, is contrived with a view to this continued action of the canal itſelf upon its contents. To prevent the inconvenience this would perpetually produce, the extremity is bounded by a ſphincter muſcle (the ſphincter ani) whoſe action is immediately under the controul of the will.

Since then the alimentary canal is conſtructed with a view of *retarding* the motion of the food along the firſt part of its courſe—it is unreaſonable to ſuppoſe, that the real and direct intention of the hepatic ſyſtem is deſtined to *haſten* its expulſion. If this were the caſe, there could not exiſt harmony between both: the inteſtines would always tend to prevent what the bile was always deſtined to produce; and the ductus communis, inſtead of opening in the duodenum, would open in the rectum.

Men who conſider the phyſiology of the ſyſtem, and can reconcile this warfare of parts that are dependent on each other, have very inadequate notions of the ſymmetry that pervades throughout the whole, and the beautiful harmony and ſubordination that exiſt between the various parts of which it is compoſed. It is far more reaſonable to conclude, thatthe bile is deſtined to harmoniſe with the inteſtinal canal, and not to defeat the intention for which it is ſo peculiarly conſtructed.

It is now only neceſſary for me to ſay, that it frequently happens that more food is introduced, than the power of the digeſtive organs can aſſimilate, and that ſome is frequently taken in totally unfit for their action. The whole forms in the ſtomach one compound maſs, from whence it is propelled by the power of its muſcular coat into the duodenum. The neceſſity of fluids therefore muſt be apparent, by which a ſeparation is effected of the pure part of the digeſted aliment from the fæculent, in order that the one may be directly applied to the ſurface of the inteſtines for the lacteals to abſorb, and that the latter may be ſeparated and expelled. I am therefore led to inveſtigate the uſe of the pancreatic juice and bile, as the agents deſtined to perform this particular office.

Of the Uſe of the Pancreatic Juice and Bile.

The contents of the ſtomach as it paſſes through the pylorus, until it reach the ductus communis, appears in general of a pappy conſiſtence, of a greyiſh colour, often ſtreaked with a white fluid, and is called chyme. After it has paſſed the ductus communis two very ſenſible effects take place: it begins to aſſume a more chylous appearance, and the contents of the ductus communis is ſeen floating on the ſurface.

Exper. A dog was fed on animal food, and in three hours the abdomen was opened: a portion of the duodenum and jejunum of conſiderable length was cut open, ſo that the contents might be obſerved. Portions of food reduced to a pultaceous maſs were ſeen oozing through the pylorus: the bile was likewiſe obſerved to paſs ſlowly out of its duct, which, when carefully attended to, appeared to flow *over the ſurface of the digeſted matter*, adhering to the inteſtines. Upon removing the bile from the ſurface of this digeſted matter, it did not appear to have mixed with it in any ſenſible degree *.

The queſtion then is, What are the agents employed to produce this ſeparation, and by what power do they act? Let us therefore examine the laws of the animated ſyſtem.

Firſt, It is a law for the whole of life in a ſtate of health to be in union with itſelf, and living parts with each other.

Secondly, It is a law of the animated ſyſtem for all living parts to ſeparate themſelves as much as they are capable from ſuch as are dead.

It is on the operation of theſe laws that the incretions and excretions are carried on, and on which the whole doctrine of digeſtion and of expulſion is founded. If therefore it can be proved that theſe fluids poſſeſs different degrees of vital energy, we ſhall be led to underſtand by what powers they ſeverally act.

That the gaſtric juice poſſeſſes the living principle in a moſt eminent degree, is proved from the quantity of blood that is conveyed to the organ by which it is formed—and by its power of imparting the general life of the animal to the food which is expoſed to its action.

---

* Dr. Saunders on the Liver, p. 123.

That the pancreatic juice poſſeſſes living properties is proved by its privation of ſenſible ones, and by its preſervative power; and Laſtly,

That bile poſſeſſes living property is proved by trying its preſervative power with thoſe of blood.

That there is a great degree of difference of living power in theſe ſeveral fluids, is proved from the change ſubſtances undergo, when expoſed to their action; by the uſes to which they are ſeverally applied; and by the difference in the quantity, and quality, of the blood out of which they are formed.

By a review of theſe circumſtances, we ſhall be led to conclude, that the gaſtric juice poſſeſſes more life than the pancreatic—the pancreatic juice more life than bile—and bile itſelf, the offspring of venous blood, which poſſeſſes even in its moſt perfect ſtate ſenſible properties, retains leſs vital energy than either of the former two.

If theſe be the different gradations of living power which theſe ſeveral fluids contain in their ſimple ſtate, we are next led to enquire their other properties in a ſtate of combination.

The portion of the food that poſſeſſed the aptitude, and received the ſtamp of vitality from the gaſtric juice, conſtitutes a part of the ſyſtem, and has a tendency to remain in union with the whole. The degree of this tendency will depend on the relation its living power bears to that of the other parts, either of the chyme, or of the pancreatic juice and bile.

It is by virtue of this tendency, and of this difference in the degree of living power, that a ſeparation in the whole of the chyme begins to take place: the pancreatic juice ſeparates the leſs vital parts of the chyme from the moſt vital: and laſtly, the bile, which poſſeſſes leſs living power than either the gaſtric or pancreatic juice, completes what the pancreatic juice had begun: and as the pancreatic juice ſeparated the leſs vital part of the chyme from the moſt pure, ſo bile ſeparates the moſt fæculent from the leſs vital. The pancreatic juice,

therefore,

therefore, forms a connecting medium between the gaſtric juice and bile.

Whilſt theſe changes are taking place, the progreſs of the chyme along the inteſtinal canal continues in a ſlow degree; the direction and number of valvulæ conniventes produce a retardation in its motion, not only for the purpoſe of allowing the action of the pancreatic juice and bile to ſeparate the fæculent parts, but that the lacteals may have time to abſorb the chylous parts alſo that have been thus ſeparated, and which are by theſe means immediately applied to the ſurface of the inteſtines. Whilſt therefore the chyle is abſorbed, the fæces are left behind. Hence it is proper to enquire, what change the bile ſuſtains by its union with fæculent matter; for there is no evidence that any part of it is abſorbed in a ſtate of health.

I have before proved, that the further bile departed from the organ by which it is produced, it was perpetually loſing its living power, and acquiring ſenſible properties. Th loſs of living power is greatly accelerated b its union with fæculent matter, after the abſorption of the chyle. Bile in this ſituation i

n

no longer that mild and bland fluid we have ſeen it in the pori biliarii. Inſtead of acting by virtue of its living power in ſeparating dead parts from living—the fæces from the chyle—it acts by virtue of the ſenſible properties of its component parts, ſtimulating the large inteſtines; which is followed by an expulſion of their contents.

The firſt portion of the inteſtinal canal, by means of the valvulæ conniventes, generally becomes in contact with the whole of its contents. Inſtead however of the canal diminiſhing in diameter, as its contents are reduced by lacteal abſorption—on the contrary, we find it increaſes in ſome of its parts. There does appear an obvious neceſſity for this mode of conſtruction—for, when the ingeſta have paſſed through the ſmall inteſtines, the lacteals having abſorbed the chyle, the fæculent parts only remain—thoſe parts that the pancreatic juice and bile had ſeparated as unfit for nutrition and ſupport. Theſe parts therefore are either prone to run into the proceſs of putrefaction, or have actually gone into it. The quantity of air that is extricated at that time, makes it neceſſary that the organs which are

deſtined

deſtined to receive the ſubſtances that undergo theſe changes ſhould be properly adapted to them. Hence the capacity of the colon, which not only admits very conſiderable diſtenſion, but by its junction with the rectum, whoſe direction is perpendicular, the expulſion of its contents is thereby facilitated.

Thus then it appears, that the primary uſe of bile is to aſſiſt the pancreatic juice in ſeparating the fæculent parts of the food from the chylous; whilſt the lacteal veſſels, which ariſe with open mouths from the internal ſurface of the inteſtines, are abſorbing the living, and leaving the fæculent.

Let it not be ſuppoſed that theſe are hypothetical and conjectural opinions. It is very true, that at the time I formed them, I had not opened the ſtomach or inteſtines of different living animals with a view of ſeeing the operations of theſe fluids upon the digeſted aliment. I am however happy to ſay, that Mr. Cooper, the gentleman I have already mentioned, has aſcertained the fact, and has abſolutely ſeen the precipitation take place, by opening the chylopoetic organs during the time that the chylopoeſis was taking place. In a letter which he has written to me upon the ſubject, "I have found," ſays he, "by opening the ſtomach and duodenum of living animals, that a clear ſolution of whatever is digeſtible is produced in the ſtomach; and that no ſooner is this tranſparent ſolution mixed with the juices from the pancreas and liver in the duodenum, but a precipitation is produced. The precipitate is the chyle, which adheres firmly to the coat of the ſmall inteſtines. I am therefore inclined to think, from experiments on living animals, that it is the office of the bile and pancreatic juice to ſeparate the nutritious from the fæculent parts of the food.

Nov. 29, 1797. "ASHLEY COOPER."

On the Secondary Uſe of Bile.

Having aſcertained the primary and moſt eſſential uſe for which bile is deſigned in ſeparating living parts from dead, I muſt proceed to point out its laſt and worſt office; when it has loſt all veſtiges of life—all the harmony it poſſeſſed with living parts—and when it irritates them to expel the ſubſtances they contain.

If the food animals received correſponded both in quantity and quality to the power of their digeſtive organs, there would be no neceſſity for the pancreatic and hepatic ſyſtems, becauſe the whole of the food would be converted into chyle, would be abſorbed by the lacteals, and there would be no fæculent parts for the pancreatic juice and bile to ſeparate. It is therefore owing to the imperfection of man, and other animals, and to the inordinate gratification of their appetites, that the exiſtence of pancreatic and hepatic organs becomes neceſſary. Hence it is that temperate men ſecrete leſs bile than intemperate. Whilſt the gall-bladder of the former is generally ſmall, and for the moſt part empty, in the latter it is generally large and full. It is owing to this entire dependence of the hepatic ſyſtem on the chylopoetic, that the different parts of which it is compoſed are ſituated and arranged; for, although the pancreatic juice and hepatic bile are perhaps adequate to anſwer common purpoſes, the neceſſity of a corps de reſerve for extraordinary occaſions muſt be apparent.

The ſtomach in point of ſituation ſeems to bear the ſame relation to the gall-bladder that it does to the pancreas: it occaſions by diſtenſion a degree of preſſure upon both; and it may be preſumed that whilſt this diſtenſion produces an evacuation of bile from the one, it will occaſion an increaſed ſecretion of pancreatic juice from the other *.

It is probable that the power of hepatic bile is ſufficient to anſwer common purpoſes without the aid of theſe auxiliary organs. On the contrary, after full meals, extraordinary aſſiſtance is neceſſary: the diſtended ſtate of the ſtomach gives the proper ſtimulus to theſe organs; and as the periſtaltic motion of the inteſtines is then in full force, the admiſſion of theſe fluids upon the ſurface of the duodenum is readily allowed. It is by this admirable contrivance that the food is ſupplied with

---

* It is with a view to this dependence of the gall-bladder on the ſtomach, that it is deprived of a muſcular coat. If it poſſeſſed a muſcular coat, it is probable that it would diſcharge its contents by an effort of the will, like the bladder of urine; but if its action depended on the will, it could not principally depend on the mechanical action of the ſtomach. Since therefore it is made to act by mechanical preſſure, the reaſon of its ſtructure, and of its particular ſituation, muſt be apparent.

bile, and pancreatic juice, in proportion to its wants, without any extraordinary action of the liver. When therefore cyſtic bile is employed, it is rather to ſtimulate than ſeparate, to produce expulſion, rather than aſſiſt chylification.

Cyſtic bile appears to me deſtined to perform the ſame office in the ſmall inteſtines, as hepatic bile does in the large. Hepatic bile, after having ſeparated in the ſmall inteſtines the fæculent parts of the food from the chylous, gradually loſes its own living power, and acquires ſenſible properties: and as its living power enabled it to ſeparate the different parts of the chyme, without ſtimulating the ſmall inteſtines; ſo by its ſenſible properties it ſtimulates the large inteſtines when unfit to perform any further act of ſeparation.

This ſeems to be nearly the ſtate of cyſtic bile by reſidence in the gall-bladder; it is perpetually loſing its living and acquiring ſenſible properties. When therefore it gets into the ſmall inteſtines, it ſtimulates them as hepatic bile does the large: by the action of the former, diarrhœa is produced; by the latter, the proper alvine excretion.

From the different properties of theſe ſeveral fluids, we are led to underſtand the reaſon why the entrance of the pancreatic and hepatic ducts into the duodenum is almoſt direct, and conveys pancreatic juice and hepatic bile into it immediately from the pancreas and liver: and on the contrary, why the gall-bladder is filled in an indirect way, and the bile it contains is only occaſionally employed. If it were conſtantly employed, the periſtaltic motion of the inteſtines would be perpetually increaſed, by the irritation it would produce, and the chyle, inſtead of being abſorbed, would be conſtantly expelled.

Since then the primary action of bile is by virtue of the living power it contains; it is very evident its acrimony and bitterneſs ariſe from the loſs of its living power, by which its primary uſe is entirely loſt. If the power of bile conſiſted merely in ſtimulating the inteſtines, cyſtic bile would be better than hepatic, and gall-ſtones would be the beſt ſtate in which it could poſſibly be found. Hepatic bile indeed would act from quantity alone, and its action be of little or no effect, becauſe it does not, and cannot, ſo long as it retains its living power, ſtimulate the ſmall inteſtines. Fœtal bile certainly does not; and it is doubtful whether hepatic bile, in the adult ſtate, ever comes in immediate contact with the inteſtines. It is not until it has loſt its living power, that it becomes acrid and ſtimulating; ſo that, when its acrimony is increaſed, its living power is diminiſhed or loſt.

Of the Omentum.

It would ſeem to be in order that the regular periſtaltic motion of the inteſtines ſhould not be influenced by the action of the abdominal muſcles in the office of expiration, that the omentum exiſts. The omentum is a broad thin membrane, attached to the great curvature of the ſtomach, to the arches of the colon, extending looſely between the interſtices of the inteſtines, and conſtituting a medium between them and the parietes of the abdomen. It is compoſed of two laminæ, placed contiguous to each other, veſicular in their fabric, and theſe veſicles are generally filled with fat; the quality of which peculiarly fits them for the uſe for which they are deſigned. The external lamina is ſufficiently moveable to yield to ſmall degrees of preſſure from the parietes of the abdomen; whilſt the internal lamina, by receiving the influence of that preſſure, prevents it, in ordinary caſes, from being communicated and felt by the abdominal viſcera.

If it were not for the protection which the omentum affords to the inteſtines, it is probable that the frequent action which the abdominal muſcles undergo in depreſſing the ribs, would generally tend to evacuate the contents of the inteſtinal canal, as they are found to do when the fæculent matter they contain is diſcharged by an effort of the will.

The omentum abounds with a larger proportion of ſebaceous matter in its centre than in its ſides, in order that the parts of the abdominal contents that are moſt expoſed to preſſure may be more perfectly protected*.

---

* During the progreſs of diſeaſe, it generally happens that the fat is abſorbed, and the omentum merely ſubſiſts as a thin membrane: inſtead of covering the inteſtines, it is thrown as it were on one ſide. I have frequently ſeen adheſion between the different convolutions of the inteſtines, when the omentum ſubſiſted in this ſtate, and apparently from the adheſive inflammation having taken place between them. This was probably owing to the want of protection from the action of the abdominal muſcles, which the omentum ought to have afforded.

Of the Chyle.

It is after the aliment has been digeſted and depurated, after the fæculent have been ſeparated from the pure parts, that this pure part has commonly received the appellation of *chyle.* In the lower order of animals, as fiſh and birds, it is generally of a thin watery appearance and conſiſtence; in the higher, as quadrupeds and the human ſpecies, it is more thick, and evidently of a globular form reſembling milk, having a ſtrong tendency to coagulate.

It appears leſs abundant in the portion of the duodenum before the entrance of the ductus communis than beyond it: it may be generally found after meals in the jejunum and ilium, rarely in the cæcum, ſeldom if ever in the colon, and never in the rectum.

Although chyle is generally of a milky white colour, it frequently participates of the colour with the ſenſible properties which the food poſſeſſed out of which it was formed. Thus it is that rhubarb or turmeric will often impart a yellow, ſaunders a red, and indigo a blue colour to the chyle.

After it has been precipitated from the undigeſted matter with which it may have been combined, and immediately involved within the folds of the valvulæ conniventes; it is taken up by abſorption by a number of ſmall capillary veſſels, that ariſe with open mouths from the whole ſurface of the ſmall inteſtines; and which have received the appellation of lacteal veſſels, from the quality of the fluid upon which they are deſtined to act, to take up and convey *.

---

* It is impoſſible for me to enter upon this part of the ſubject without mentioning Mr. Cruickſhank's book upon the Abſorbent Syſtem; a book that contains every thing that has ever been ſaid of conſequence upon it; which ſeems to have exhauſted the ſubject, and which it muſt be allowed does the author great credit.

CHAP.

CHAP. XIII.

OF THE LACTEAL VESSELS.

Their ſource—their fabric—their action—the quality of the matter they take up—the quantity—the relative degree of their action at different periods of life—&c. &c.

SUCH is the extreme minuteneſs of the origin of theſe veſſels, that, if it were not for the abſorbent effects they produce, we ſhould be unable to decide from whence their origin begins. Seeing however, as we have conſtant opportunities of doing, that the chyle which the inteſtines contained is continually taken up; and that the fluid in the lacteals is exactly the ſame in its properties as that which previouſly exiſted in the inteſtinal canal, we are naturally led to infer that it is by thoſe veſſels that it is immediately taken up. Thus it is, that although the contents of the lacteals is generally white or milky, it is occaſionally found of a yellow, of a red, or of a blue colour. To aſcertain this point, indigo blue in union with water was injected in the ſmall inteſtines of a living dog: after a ſhort time he was killed and opened, and the colour of the abſorbed fluid exactly correſponded with that which had been thrown into the inteſtines. Not theſe facts alone prove their power of abſorption; but they have occaſionally been tied up at ſome diſtance from the inteſtines, and the ſpace between the inteſtine and the ligature was generally found filled with chylous matter.

Aſſuming it then as a fact, that it is by them that chyle is abſorbed, it is neceſſary for me to deſcribe the mode of their conſtruction, and the part in which they terminate. When the villous coat of the ſmall inteſtine is examined with a microſcope, it appears like the villi of velvet; and it ſeemed to Dr. William Hunter, who examined them with the ſame inſtrument, that from each of theſe villi there were at leaſt fifteen or twenty, or more orifices. Wonderful then is the proviſion by which the food, after it has been aſſimilated, may be taken up! It is not from the extent of the ſurface alone by which they are diſtinguiſhed, but by the active power alſo which they ſeem ſeverally to poſſeſs. Mr. Cruickſhank found in ſome experiments which he made, that the chyle was conveyed through the lacteals in the meſentery of a living dog at the very rapid rate of four inches in length in one ſecond of a minute; or, in other words, that it deſcribed a ſpace of twenty feet in one minute. No wonder then that the whole of the ſyſtem becomes ſo ſuddenly renovated by cordials and other ſpecies of nouriſhment at particular times.

Although it is generally admitted, that the lacteals conſtitute the agents by the energy of which chyle is taken up from the inteſtinal canal, a great variety ſtill exiſts as to the mode by which the effect is produced. Baron Haller, De Whytte, and a number of men in our own days, ſtrongly inſiſt that it proceeds from capillary attraction. This opinion, however, was ſtrongly combated by Mr. Hunter: he conceived on the contrary, that it proceeded from a vital power reſident in the abſorbents themſelves, and was an action of which a living

ing and not a mechanical power was the cauſe. When a tube pierced with a very fine bore, and open at both ends, is immerſed in a fluid, it is very true that that fluid will progreſſively aſcend in it to a certain height. This effect, however, is regular and conſtant, is not liable to remiſſions or increaſe; but the effect produced is invariably the ſame. But this is far from being the caſe with the abſorption that the chyle ſuſtains by the power of the lacteals: inſtead of being equal at all times, it perpetually varies, being ſometimes more active, at others more languid; and finally terminates altogether ſoon after the actions of the animated ſyſtem have ceaſed. If the abſorption of chyle aroſe from capillary attraction, as we behold in ordinary caſes, abſorption would take place more completely perhaps in the dead than in the living ſubject, which it does not. We may therefore conclude that it is not a chemical but a vital act, ariſing from the inherent power which the lacteal veſſels contain.

That theſe lacteal veſſels poſſeſs different coats, Mr. Cruickſhank aſcertained by inveſting a portion of the thoracic duct upon a glaſs cylinder ſomewhat larger than the duct itſelf.

He found that the internal coat tore, and ſhewed the external one under it perfect and entire. Such is the active power which theſe veſſels contain, that we are from analogy led to conclude that this power is reſident in a muſcular coat ſimilar to what the arteries poſſeſs, and that the motion of the fluid they convey is performed by one and the ſame mean.

The lacteals are found to abound in their internal part with valves: theſe valves are of a ſemicircular figure, and are attached to the inſide of the veſſels by which they are encloſed. It is likely that theſe valves are eſpecially deſigned to prevent the retrograde motion of the fluid which the veſſels contain; that whilſt they permit it to flow through they prevent it from returning back. This is the general opinion. Is it not however very probable, that theſe valves themſelves poſſeſs a muſcular coat, and that they not only prevent the return of the abſorbed fluid, but that they may urge it on by a power from behind, and by that mean aſſiſt the coats of the veſſels themſelves? I think the mode of their attachment and the imperfection of their valvular conſtruction favour the idea. They only fill one half of the veſſel, and are therefore diſpoſed of in pairs at ſome diſtance, correſponding and oppoſite to each other, floating looſely in the lacteal veſſel itſelf. The ſpace between the origin and the termination of the lacteals progreſſively decreaſes, from two or three inches in the ſmall, to half an inch in the large inteſtine. Theſe veſſels are generally known by the common name of vaſa inferentia, or venæ lacteæ primi generis, and terminate in ſmall glandular bodies, called, from the part on which they are ſituated, meſenteric glands.

The meſenteric glands, like the lacteal veſſels, although ſcarcely to be diſcovered in the fœtal ſtate, are relatively larger to the ſize of the ſyſtem in infancy and youth, than in the latter period of manhood, and eſpecially of old age. They are not only larger but redder in the young than in the old, owing probably to a difference in the quantity of blood they receive. The venerable Ruyſch, that old octogenarian, uſed to ſay, that he had lived for the laſt ten years of his life without the aſſiſtance of his lacteal veſſels or meſenteric glands.

It is difficult to ſtate what is the immediate purpoſe for which theſe glands are deſigned. It appears however very probable, that the fluid which has been digeſted, and which is conveyed into them, undergoes a further change, and becomes more perfectly aſſimilated. Although in common they are of an aſh colour, they appear white during the abſorption of chyle. That the vaſa inferentia terminate in theſe glands, ſeems probable from hence, that the number of veſſels that go in do not correſpond with thoſe that come out. The veſſels that come out of the meſenteric glands are called venæ lacteæ ſecundi generis, or vaſa efferentia: they are generally larger than the former, and fewer in number; and theſe again terminate in glands of a ſimilar kind. Other veſſels again ariſe from theſe glands, until at length they progreſſively unite into one trunk, forming one conſtituent portion of the thoracic duct.

CHAP. XIV.

OF THE LYMPHATIC ABSORBENT VESSELS.

Divided into two ſets—1ſt, thoſe that ariſe from the ſurface of the body, and abſorb things from without—2dly, thoſe that ariſe from within, and abſorb different parts of the ſyſtem itſelf—their actions excited under different circumſtances, which are particularly ſtated—Mr. Hunter's opinion examined and proved to be an erroneous one, &c. &c. &c.

IT is not through the medium of the lacteal veſſels alone, which ariſe from the ſurface of the ſmall inteſtines, that the blood is ſupplied with nouriſhment and ſupport: it receives a conſtant and conſiderable addition from the medium in which the ſyſtem is ſituated, by abſorption from the ſurface of the ſkin; and finally, from the different parts of the animated ſyſtem itſelf, after thoſe parts have fulfilled the end for which they were deſigned—when they are loſing, or after they have actually loſt, their living and preſervative properties, and are verging to a dying ſtate.

The powers or agents by which this effect is produced, are called *lymphatic abſorbent veſſels.*

I ſhall divide them into two ſpecies: firſt, thoſe that ariſe from the ſurface of the ſkin, and take up fluids external to the body; and ſecondly, thoſe that ariſe from the internal parts of the ſyſtem itſelf, whether from circumſcribed cavities, or from the ſolid fabric of every organ, and which abſorb portions of that ſyſtem, both ſolids and fluids alſo.

Of the Lymphatic Abſorbent Veſſels of the Skin.

In point of conſtruction and mode of action, theſe veſſels reſemble the lacteal abſorbent veſſels, which I have already deſcribed; they differ from them only in the ſituation from whence their origin begins, and in the quality of the matter which they abſorb. Such is the ſubtilty of their orifices, that, although we are able to trace in a retrograde manner the fibrils as far as the ſkin itſelf, we are unable to behold the orifices themſelves—although, deprived of the evidence of our ſenſes, we have proof ſufficient of their actual exiſtence.

That the lymphatics ariſe from the ſkin, is proved in a moſt decided manner from hence, that ſubſtances which are rubbed on its ſurface may be often detected in different parts of the body. Thus it is that mercury, after having been triturated with axunge, is abſorbed from the ſkin (after friction has been uſed), is conveyed into the blood, and afterwards depoſited in particular parts, producing its ſpecific mode of irritation. It has I know been doubted, diſputed, and denied, that mercury in a ſolid and palpable form was ever taken up from the ſkin. The fact however muſt be ſtated, that Longbottom, the articulator, had in his poſſeſſion the ſkeleton of a man, who died after a long courſe of mercury, when particles of mercury were actually found in the cancelli of the bones.

There is alſo reaſon to believe that different morbid poiſons, when applied to the ſurface of the cuticle, are frequently abſorbed from it, as the poiſon of ſmall pox, of ſyphilis, &c. &c.

Admitting the fact that the lymphatic veſſels ariſe from the ſkin, and convey things from without to the ſyſtem itſelf, it would naturally become a curious matter if we were able to aſcertain the power they are capable of exerciſing. The different ſtatical experiments that have been made with that view, although they eſtabliſh the general fact, are liable to deception when we wiſh to aſcertain the quantity in particular. I cannot however give a more ſtriking illuſtration of the power which theſe abſorbent veſſels are found occaſionally to exert, than by referring the reader to the different caſes which he may have ſeen of diabetes melitus; when the quantity of fluids that are excreted by urine for months together, ſurpaſs in an almoſt infinite degree the quantity that has been received into the ſtomach, and which it is moſt probable were abſorbed from the ſurface of the ſkin by the lymphatics. There have been ſome caſes of this kind lately publiſhed by Dr. Rollo, to which the reader muſt refer. Theſe veſſels, like the lacteals, anaſtamoſe with each other. In the extremities they proceed a conſiderable way in this manner before they terminate in lymphatic glands: on the contrary, theſe glands are more numerous in the abdomen and thorax, and the lymphatic veſſels dip into them at ſhort diſtances.

Of the Lymphatic Abſorbent Veſſels of the Internal Parts.

Such is the periſhable condition of all generated beings, that they are in a perpetual ſtate of mutation and decay: governed as they are by the fleeting meaſure of time, they loſe every inſtant the identity of their nature: the parts that are received from without, and which have obtained the participation of life, are conſtantly loſing that participation, and verging to a dying ſtate. Hence ariſes the neceſſity of veſſels that are deſtined to remove the different parts of which the animated ſyſtem is compoſed, as ſoon as they are diſqualified to anſwer the purpoſe for which they were organized. If it were not for the action of theſe veſſels, the different parts would undergo the ſame putrefactive changes in the ſyſtem, that they invariably do out of it; and thus it would happen, that every animated body would be a compound of life and death, of animal matter in a ſtate of action and of ſelf-preſervation, and of animal matter in a ſtate of putrefaction. It is far otherwiſe. Every living ſyſtem is conſtituted in the beſt poſſible way to anſwer the final cauſe of its exiſtence; and as it is ſupplied with organs by means of which a ſupply is produced, ſo it is endowed with the means of removing the parts that are waſted and decayed: it is this important office for which this third order of abſorbent veſſels are eſpecially allotted.

They ariſe, like thoſe we have already deſcribed, with open mouths from the internal ſurface of circumſcribed cavities; from the different interſtitial parts of the ſyſtem, from the ſoft texture of muſcles, from the ſolid fabric of bones, and, in ſhort, from every part that is diſtinguiſhed by any organization. The abſolute neceſſity of theſe veſſels will be more apparent, if we revert to the different periods of evolution which different organs ſuſtain, and the progreſſive decay they undergo after they have anſwered the end for which they were formed. Thus it is that the thymus gland, which is of conſiderable magnitude in the fœtal ſtate, and which, no doubt, anſwers ſome office (unknown indeed to us), is taken up and removed;—that the alveoli which incloſe the milk teeth, are abſorbed in proportion as the evolution of the ſecond ſet takes place. It is by their action that the immenſe magnitude which the uterus has attained during the period of geſtation becomes diminiſhed and reduced to its original ſize, after parturition has taken place. During the virgin or unimpregnated ſtate of this organ theſe veſſels can ſcarcely be detected. On the contrary, when they are employed in pulling down and unbuilding the fabric of this organ, they acquire the enormous ſize of a quill.

It is through the energy of theſe veſſels that the cancelli of the bones are abſorbed, and that morbid tumours are diſperſed; that the preternatural accumulation of ſerum and pus in circumſcribed cavities, as the thorax, abdomen, and ſcrotum, is frequently removed, the ulceration of the integuments effected, and accumulation of purulent matter diſcharged. They in fact ſeem deſigned to preſerve the ſyſtem in a ſound condition, by acting upon and removing the parts of which it is compoſed, that are in a ſtate of diſeaſe; or, when preternatural accumulation exiſts, that might impede the functions of parts, or bereave them of the power of acting. The active power which theſe veſſels poſſeſs, has been aſcertained by various experiments. Six pints of warm water were injected in the abdomen of a living dog: ſix hours after he was killed and opened, and four ounces only of the fluid was found to remain; and it muſt have often fallen to the obſervation of moſt practitioners, to have ſeen great accumulations of water in the abdomen removed in a very ſhort time by the energy of theſe veſſels.

That theſe veſſels are deſtined to preſerve the ſyſtem in a ſtate of health, by removing the parts of it which are dying and diſeaſed, is further proved from the emaciation which we behold in conſequence of their actions, during the progreſs of nearly all complaints, whether they are produced by that worm that always accompanies anxiety of mind, or corporeal cauſes of a morbid kind. This idea is further corroborated from the rapid manner in which the effect is produced in diſeaſes of debility, as the ſcurvy, typhus fever, &c. It is proved alſo from abſorption taking place in weak rather than in ſtrong parts, in ſuch as have been newly formed, than in thoſe of an original conſtruction. Thus it is that we have ulceration of the ſkin from preſſure—of the gums, from ſcurvy; and we are informed

formed by the elegant author of Lord Anſon's Voyage, that ſome of the ſeamen that had fractured bones, and which had been united for many years, had the connecting callus abſorbed, and the fracture reproduced, without any exciting cauſe externally applied.

That weakneſs of the ſolids and fluids of the animated ſyſtem excites the action of the lymphatic abſorbent veſſels, is further proved from the impreſſion of fear. A friend of mine had a boy under his care, having a large collection of ſerum in the abdominal cavity, which he had determined to evacuate by the operation of tapping. On the day that the operation was to be performed, the boy was ſeized with ſuch terror, that it was thought prudent to ſuſpend the operation. On examining the abdomen the next day, it was found to be conſiderably ſofter, and that a conſiderable abſorption of the fluid had taken place: it continued from that time progreſſively to increaſe, and in a ſhort time the fluid totally diſappeared.

Malpighi was of opinion, that the action of theſe veſſels continued after the other actions of the ſyſtem had ceaſed; and inſtituted ſome experiments to prove his aſſertion. The fact however was aſcertained by Mr. Cruickſhank. He tied up the trunks of the arteries and veins belonging to a portion of the great inteſtines of an aſs, after it had been dead a few minutes, (the inteſtines were ſtill in the cavity of the abdomen, and the parts were not cold). "I knew," ſays he, "that the trunks of the abſorbents muſt be encloſed in the ligature, although not one of them was then viſible. Two hours after I returned, and found a number of abſorbents tinged with a tranſparent lymph. I opened one of the largeſt with a lancet. The fluid iſſued in a ſtream; which it could not have done, unleſs the veſſels had continued to abſorb or to propel their fluids with great force after the death of the ſyſtem *."

And finally, I have frequently ſeen large œdematous ſwellings on the feet completely removed after the total ſuſpenſion of reſpiration, not from a more extended diffuſion of the ſerum in the cells of the cellular membrane, becauſe the poſition of the limbs continued the

---

* See his Treatiſe on the Abſorbents.

ſame all the time; it could only proceed from the action of the lymphatics having continued after the action of the vaſcular ſyſtem had terminated.

That the action of theſe veſſels continues under the loweſt poſſible ſtate of general debility that can be conceived, is proved by the phenomena we behold in torpid animals. It is a fact that the bears in Greenland, during the ſummer and autumnal months, are remarkable for the quantity of fat with which they abound, until they become torpid. They remain in this ſtate during the long period of a polar winter, and when the ſpring returns they are always found bereaved of all their fat, emaciated and lean: an evident proof, that although the general actions of the ſyſtem were ſuſpended, thoſe of the lymphatics ſtill continued *.

We may therefore conclude, that the lym-

---

* Such is the voracity of theſe animals when ſtrongly impelled by the call of hunger, that they have been known to faſten upon the back of a whale, to tear and devour a part of it. The whale immediately dives as deep in the water as its lungs will allow; and the bear has been ſeen to have continued and preſerved its graſp until the whale was again obliged to riſe upon the ſurface.

phatic abſorbent veſſels are eſpecially allotted the office of removing the different parts of the ſyſtem that are either ſuperfluous or diſeaſed, in order that the whole may be preſerved in a healthy ſtate.

Great then muſt have been the error of Mr. Hunter in having aſcribed the office of modellers of our frame to this deſtructive ſyſtem of veſſels, that diminiſh the fabric of the whole by the parts they abſorb, and often deſtroy the form itſelf; that are only deſtined to remove the parts of the ſyſtem that are unfit to ſupport the model, although once conſtituting a portion of it. They bear the ſame relation to the modellers that the common labourer does to the architect, being deſtined alone to pull down and carry away the materials that are worn out and unfit for the ſupport of the machine. It is inconſiſtent with common ſenſe to aſcribe the office of modellers to organs, that remove without producing, that take down the whole fabric inſtead of faſhioning it: this is miſtaking an effect for a cauſe, the beginning for the end. It is in fact, and I beg pardon for the expreſſion, both contradictory and abſurd to aſcribe to them ſuch an office. Mr. Hunter and his followers may contemplate with admiration, the exquiſite beauty that exiſts in the model of a jaw deprived by the action of the lymphatics, of ſockets and of teeth, and in the phagædenic ulceration of an extended ſurface. But he will never perſuade me, that the ſyſtem of veſſels that is allotted to perform theſe deſtructive actions, are thoſe by which the beautiful enamel and the poliſhed ſurface are laid.

Theſe veſſels anaſtamoſe with the other lymphatics of the ſyſtem, as well as with the lacteals in the abdomen. Theſe different branches generally congregate together into two, one on each ſide, before they ultimately unite, and form, with the addition of the one which I have already deſcribed from the lacteals, the thoracic duct *.

---

* Mr. Hewſon was of opinion, that it was this matter which the lymphatics had abſorbed that conſtituted the central particle obſervable in the red globules. I confeſs that I am very much diſpoſed to think that he is right—although evidently wrong in the uſe which he aſcribed to the ſpleen as being ſubſervient to this office alſo.

The Thoracic Duct.

It varies in magnitude in different ſubjects: in ſome it is not above an eighth of an inch in diameter; in others it is as much as a quarter; in ſome it is not twelve inches long, in others it is from ſixteen to eighteen.

It generally begins on the left ſide of the ſpine, about the third vertebra of the loins: it afterwards proceeds along the right of the firſt lumbar and dorſal vertebræ, the four uppermoſt excepted: it then re-paſſes from the right to the left ſide, emerging from the cavity of the cheſt, about one inch above its deſtined termination; thence proceeds downwards, forming an arch by this deſcent; and finally terminates in the angle which is formed between the left jugular and ſubclavian veins.

CHAP. XV.

OF THE VEINS.

Their origin—their fabric—their mode of termination—the difference of them from arteries pointed out—the power by which the blood is propelled through them—the term circulation diſputed, &c. &c.

IT is unneceſſary for me, after having given a general deſcription of the arteries, to ſearch for the origin of the different veins. It ſuffices to ſay, that beſides the exhalant outlet which arteries poſſeſs, and through the medium of which a quantity of fluid is conſtantly diſcharged for the purpoſe of ſecretion, and which we have already noticed, the portion of the blood which is not employed for that purpoſe, flows through a continuous canal which takes a retrograde courſe : it is this veſſel which brings and returns the reſiduary part of the blood, that is called a vein, and which begins where the artery terminates.

Veins vary very materially in their conſtruction from arteries; they poſſeſs leſs elaſtic ligament, and become flaccid and collapſed when empty of their blood. On the contrary, ſuch is the elaſticity of the arteries, that they preſerve their circular form, although deprived of any fluid whatever. Arteries diminiſh in ſize and increaſe in muſcularity as they proceed from their origin to their termination. On the contrary, veins have a ſmall origin, and increaſe in ſize and in muſcularity as they proceed to their termination in the heart. Arteries are deſtitute of valves. On the contrary, veins abound with them. And finally, arteries are deſtined to convey blood from the lungs through the medium of the heart to the different parts of the ſyſtem. On the contrary, veins are deſtined to return blood from the different parts of the ſyſtem, through the medium of the heart, that it may be conveyed back to the lungs.

Arteries multiply and ramify as they proceed from the heart. On the contrary, veins congregate and truncate as they approach to it. Arteries proceed at acuter angles from their trunk, in proportion as they recede from the aorta. On the contrary, veins have no definite angle at which their branches enter their trunks, and they anaſtamoſe with each other more frequently than arteries.

It is generally believed that the motion of the blood through the veins is effected by the vis a tergo from the arteries. However reaſonable it may be, that this impulſe which the blood has received from the arteries may propel it ſome diſtance in the ſmall veins, it ſeems very improbable to me that this motion is continued in the larger branches, more eſpecially as they approximate to the heart. The veins bear the ſame relation to the arteries, with reſpect to the motion they receive from them, as the arteries do to the left ventricle of the heart. The arteries gradually diminiſh in ſize as they recede from the heart: the veins gradually enlarge as they approach to it. If it be allowed that this mode of conſtruction is favourable to the propulſion of the blood, by the power of the left ventricle, into the arteries, ſurely it is moſt unphiloſophical to ſuppoſe that a conſtruction totally different is favourable for the production of the ſame effect by virtue of the ſame power*. It ſeems, I confeſs, more probable to me, that the veins convey the blood they contain for the moſt part by an inherent power of their own, receiving but little aſſiſtance from the arteries.

The veins take up blood from the corpora cavernoſa, and propel it without any vis a tergo from the arteries. In amputated limbs, the blood in the veins is conveyed by the ſame force. Why then ſhould we deny them the ſame power which we have ſeen the lymphatic veſſels poſſeſs in ſo eminent a degree?—veſſels that we are ſure receive no propelling power from any auxiliary organs, and whoſe valvular conſtruction is ſimilar to that which we behold in veins in general.

---

* It is ſomewhat remarkable, that, upon ſo ſimple a queſtion as this, ſuch an uncertainty ſhould ſtill prevail. I have put the queſtion to ſeveral of the moſt eminent anatomiſts in London. Some think that it was effected principally by the vis a tergo from the arteries; and that valves in the veins, by ſuſpending the column of blood, whilſt they prevent the preſſure of it, allow it to preſerve the motion communicated to it from the arteries: nay, more, they had ſeen the veins occaſionally pulſate, and the pulſation was ſynchronous with that of the arteries. Others again are of a totally different opinion, and aſcribe the effect to the veins alone.

The blood which is returned from the head, is conveyed by three branches, by the external and internal jugular veins, aſſiſted by the vertebral. Theſe three veins correſpond to the three arteries which convey blood to it. From the ſuperior extremities the blood is returned by veins that have received particular names, and that are differently ſituated, as cephalica, media, and baſilica. Theſe different veins, after running along the inſide of the fore-arm, and anaſtamoſing very freely, by means of the ramifications, of which their trunks are ultimately formed, paſs the bend of the arm, and proceed towards the outer edge of the external portion of the biceps muſcle; and after going between the pectoral and deltoid muſcles, terminate in the axillary vein, from its ſituation in the axilla. The axillary veins therefore are formed by the united branches of the veins from the ſuperior extremities, with the addition of thoſe that ariſe from the different muſcles ſituated about the ſcapula and thorax.

It is by the congregation of theſe different trunks of the jugular, axillary, and vertebral, that the ſubclavian veins are formed. The two ſubclavian veins, the right and left, after approximating each other in the ſuperior part of the thorax, unite into one trunk, and the vein thus formed is called vena cava ſuperior. The cava ſuperior receives the addition of a conſiderable trunk called vena azygos, which is itſelf formed by the united branches of the intercoſtal veins, and from other veins derived from different parts of the cheſt.

From the lower parts of the body the blood is returned by the medium of veins conſtructed in the ſame way, and arranged in the ſame manner as thoſe we have already deſcribed, deriving their appellation either from the organ from whence they ariſe, or from the artery of which they are a continuation. It ſuffices to ſay, that they all, like thoſe from the ſuperior part of the ſyſtem, ultimately unite into one trunk, and form the vena cava inferior.

The vena cava inferior, after piercing the diaphragm, penetrates the pericardium ; it unites with the vena cava ſuperior, and enters in one trunk the right auricle of the heart.

It is owing to the high degree of deterioration which the blood ſuſtains in the moſt rational beings, in conſequence of the ſupply it affords to the different organs through which the various functions both of body and of mind are carried on, that the neceſſity abſolutely ariſes for an increaſed degree of power by which it is returned to the lungs, and for a more extended power in the lungs themſelves. Thus it is that we are led to comprehend the cauſe, why the organ by means of which the blood in the fœtal ſtate is purified and formed is different from that of the adult, as well as the organ by whoſe power it is eſpecially conveyed; in the one caſe, where there is evolution only without general action; in the other, where there is evolution and general action together. Inſtead of one third part of the blood flowing from the right auricle to the left, without going to the ventricle, the whole flows into the right ventricle. It is prevented from regurgitating into the auricle by the medium of the tricuſpid valves; and inſtead of another third part or more flowing through the medium of the ductus arterioſus immediately into the aorta, the whole blood is propelled by the contraction of the right ventricle, through the medium of the pulmonary arteries, into the lungs. The blood is prevented from returning from the pulmonary artery into the ventricle by three ſemilunar valves, or of flowing into the aorta through the ductus arterioſus, by the total obliteration of that canal. It is therefore propelled through the medium of the pulmonary artery wholly and ſolely into the lungs, not only with a view of being again meliorated, as we have ſeen it was, by the union with caloric, or of vital air; but that the impure parts may be ſeparated from the maſs through the exhalant extremity of the pulmonary artery, and expelled as deleterious and foreign. It is this act of expulſion in which *expiration* conſiſts.—By inſpiration, therefore, air is received into the lungs; by *digeſtion*, the pure portions of the whole are aſſimilated and abſorbed; and by *expiration*, the impure parts are ſeparated and diſcharged: ſo that the whole taken together conſtitutes the phenomenon of *reſpiration*, the final cauſe of which is the *perfection of ſanguification.*

CHAP. XVI.

OF THE DIFFERENT DEGREES OF POWER IN THE VASCULAR ORGANS OF DIFFERENT SYSTEMS.

In vegetables—in fiſh—in amphibia and animals of an higher claſs—the relative degree of velocity with which the blood is moved in theſe different ſyſtems.

IT is owing to the high degree of vitality which the different ſyſtems poſſeſs, which I have deſcribed, to the ſmall degree of waſte which they conſequently ſuſtain from the limited nature of the actions they ſeverally perform, that we behold the organs by which the blood is conveyed, ſo comparatively ſmall with reſpect to quadrupeds in general, and the human ſpecies in particular.

The medulla of vegetables is propelled either by a vis a tergo from the roots, or by the power of the ſap veſſels alone. In fiſh, the blood is received from the branchiæ by a multitude of veins that ariſe from the ſurface of that organ, and which ſeem analogous to the pulmonary veins of the moſt complicated animal. Although they are analogous to them in their origin, they are totally different from them in their termination. Inſtead of congregating together like the pulmonary veins, and uniting in the left auricle, that they may be conveyed by the power of the ventricle through the aorta to the different parts of the body; the branchial veins do not enter the heart; they form at once an aorta, a ſhort way from the gills, without the intervention of a heart. The aorta divides into different trunks, and ſupplies the different parts of the body with living blood: the blood is returned from the different parts of the ſyſtem, as in other animals, by two veins of conſiderable magnitude, which terminate in a heart. The ſimplicity of the heart in fiſh correſponds to the nature of its functions. It is only deſtined to receive the blood from the different parts of the ſyſtem, and to convey it to the branchiæ. It is therefore compoſed of an auricle and of a ventricle; of *one* auricle by which the blood is received, and of *one* ventricle by which it is conveyed—received from all the different parts of the body by the medium of different veins—conveyed through the medium of the pulmonary artery to one part—to the branchiæ, as the ſanguifying organ of the ſyſtem, in order that the blood may be meliorated and fitted to anſwer the purpoſes of nutrition and of ſecretion. It is therefore from the branchiæ the motion of the blood begins; it is in the branchiæ that it terminates. The branchial arteries divide upon the branchiæ into an infinite multitude of fibrillæ, giving the gills the feathery appearance they diſplay. Such is the indefinite ſubdiviſion of the termination of the branchial artery, that the power of the ventricle of the heart upon its contents muſt be trifling and weak. Such however is the aptitude to be moved which the blood contains in conſequence of the action of the branchiæ, that the branchial veins alone have the power to propel it to the different parts of the ſyſtem; the motion of the blood in fiſh, as it proceeds from the lungs, muſt conſequently be very ſlow.

The degree of its motion, like the medulla of plants, correſponds to the wants of the ſyſtem, and to the little waſte it ſuſtains. Such is the degree of deterioration which the blood undergoes in its progreſs through the ſyſtem, that the organization progreſſively increaſes in ſtrength. The branchial veins at their origin are extremely pellucid and thin; but in proportion as they congregate and form an aorta, the organization becomes more turgid and ſtrong. The returning blood therefore requires the power of an heart, that it may be propelled into the lungs, and again receive the vitality which it had loſt, by the ſecretion of its pureſt part from the exhalant termination of the different arteries. The motion of the blood therefore in fiſh differs from the motion of the medulla of vegetables in this: the motion of the medulla aſcends only, without deſcending; the motion of the blood in fiſh both aſcends and deſcends: inſtead of moving progreſſively as the ſap, without the intervention of a particular power (a heart), it is returned by the power of the heart to the gills (or lungs), when the ſame proceſs again begins.

As we proceed from fiſh that have gills, to the amphibia that have lungs, we find the power by which the blood is conveyed progreſſively

greſſively to increaſe. It is received from the lungs by the pulmonary veins, as it is in fiſh by the branchial; but inſtead of being immediately diſtributed by means of an aorta to the different parts of the body, the pulmonary veins ultimately unite, and enter the left auricle of the heart, which in them is very large, and terminate in the ventricle, which is comparatively ſmall. It is from this ventricle that the aorta proceeds, and diſtributes the blood by different trunks to different organs, and to different parts. The reſiduary part of the blood is returned to the right auricle of the heart *.

The

---

* The vaſcular organization of the amphibia ſeems to correſpond in a great degree to the vaſcular organization of the fœtal ſtate. In the higher order of animals, the blood which the umbilical veins receive from the placenta, after having been diſtributed to the different parts of the body, returns into the right auricle of the heart. Part of the blood which the right auricle receives goes into the left auricle, through the medium of the foramen ovale; the remainder paſſes into the right ventricle. This ventricle propels the largeſt portion of it through the duĉtus arterioſus to the aorta, and the pulmonary artery only receives a quantity ſufficient to preſerve it in a patent ſtate; and as the lungs are perfeĉtly paſſive, they conſequently exert no influence upon it.

The blood which the right auricle receives paſſes into the ventricle. For, in amphibia, the two ventricles may be conſidered as forming only one cavity, from which both the aorta and pulmonary arteries ariſe; whilſt the blood which is returned from the lungs mixes with that in the ventricle which is returned by the cava; ſo that there is half arterial and half venal blood, and not more than one third part of the whole is found neceſſary to move through the lungs to be renovated *.

It is this ſanguifying organ which conſtitutes the medium between the beginning and the end of the circulation. It is in the origin of the pulmonary vein where the blood is perfected and prepared, and fitted to anſwer the purpoſe of nouriſhment and ſupport, that

---

The placenta therefore conſtitutes the ſanguifying organ of the fœtus, as the lungs do of the amphibia. Such is the ſufficiency of the placenta, and the comparative ſmallneſs of deterioration which the fœtal blood ſuſtains, that, like the blood of the amphibia, that which the pulmonary artery conveys is not much blacker than the blood the pulmonary veins receive.

[*] Amphibia have a power of occaſionally ſeparating arterial from venal blood, by a ſeptum in the right ventricle.

the punctum ſaliens of the blood exiſts. It is in the extremity of the pulmonary artery where it parts with its azotic and carbonaceous properties, after it has gone through the courſe of the ſyſtem which conſtitutes the punctum ultimum of the whole.

Seeing then that there is an organ by which blood is perfected, and a point where that ſtate of perfection is obtained, and from whence the blood proceeds, the term circulation appears to me a diſputable one. The conſtruction of the vaſcular ſyſtem indeed neither bears an analogy to a circle, nor the motion of the blood to a circulation. A circle is a figure bounded by a circumference, and all the parts of that circumference are equally diſtant from the centre, and in that circumference there is either beginning, middle, or end. It is, in fact, a whole without parts; becauſe, the inſtant the circumference is divided, the circle is deſtroyed, and the figure no longer conſtitutes a circle. The vaſcular ſyſtem is conſtructed in a manner totally different. The parts of the pulmonary veins which receive the blood in its pureſt ſtate, have a beginning; the parts of the pulmonary arteries that return the worſt blood have an

end.

end. The blood therefore originates from a beſt part—proceeds and terminates in a worſe. If it bore any analogy to a circle, there would be no ſuch difference, but all the parts would be equal and alike.

Neither does the blood which the vaſcular ſyſtem conveys bear any analogy to a circulation. A circulation, properly defined, is that which perpetually returns into itſelf. This is not the caſe with the medulla of vegetables: the whole moves, and no part returns. It is not the caſe with the amphibia: the whole moves and paſſes through the heart, and part only paſſes through the lungs: and in the higher order of animals, the whole moves, and part only circulates. If the whole of the blood circulated, that is, returned back into itſelf, the very end would be defeated for which blood was eſpecially deſigned. If the blood circulated and returned into itſelf, how could it afford nouriſhment to parts, and ſupply the different glands of the ſyſtem? To prevent the blood from circulating and returning into itſelf, it appears that the veſſels by which it is conveyed are particularly and expreſsly conſtructed; it is conveyed to the different parts of the body through the medium of arteries. Theſe arteries have two modes of termination ; one into an exhalant outlet, another into a returning vein. The portion of the blood which is effuſed from the exhalant outlet, is the portion for which the motion of the blood is expreſsly intended ; it is the part which is intended to ſupply the waſte which the machine ſuſtains, or to be ſubſervient to the particular action of glands. The portion of the blood which is brought back by the returning vein, and which actually does circulate, anſwers no one purpoſe in the ſyſtem which blood is intended to do ; it conſtitutes the reſiduary matter only, the refuſe of the whole ; the globules too groſs and too coagulated to be exhaled through the capillary extremity of the arteries, too azotic to afford nouriſhment to dying, too impure to be acted upon by living parts.

The queſtion therefore ariſes, whether we are to give the motion which the blood ſuſtains, the appellation of circulation, or not. If we give the name of a thing from the very eſſence of it, and from the portion of it which is uſeful, and which does not circulate, we muſt abandon the term circulation. On the contrary, ry, if we take the part of the blood which is the worſe, and which is uſeleſs, we may continue the term circulation. Although this is evidently inadequate and inapplicable, we may continue the old abſurd cuſtom of beginning to deſcribe the circulation of the blood in the *middle* of its courſe,—that is, from the heart,—and end in the *middle* of its courſe,—that is, in the heart*.

Of the relative Degree of Velocity with which the Blood is moved in different Animated Syſtems.

If we examine the nature of different animated beings, and the different ſtates and conditions in which the blood is found to ſubſiſt in them, we ſhall be led to conclude, that the degree of its motion entirely depends on the wants of that ſyſtem of which the blood forms a part; and that this want proceeds from the degree and variety of action, each particular ſyſtem is deſtined to perform.

---

* It has indeed ever been painful to me, to hear anatomiſts and phyſiologiſts deſcribe the circulation. They ſay it is of no conſequence at what point they begin, whether at the right ſide of the heart, or on the left; whether at the pulmonary artery, or the pulmonary vein; that is, at the end or at the beginning of its courſe. Such vague and indefinite notions of the moving power by which the blood is conveyed, give us no idea of the uſe for which it is deſigned, or of the organs by which it is perfected and produced.

During the period in which the vegetable ſyſtem is in a torpid ſtate, the medulla, inſtead of moving, is perfectly ſtagnant; on the contrary, when the evolution of the different parts takes place, and more eſpecially when they are actively employed in fulfilling the final cauſe of their exiſtence, in the production of fructification, we find that the ſap, or medulla, progreſſively aſcends from the roots, and that the degree of its motion is conſiderably accelerated.

We are able to behold the ſame variety in a more eminent degree in fiſh, and in the greateſt number of the amphibious claſs. In the winter, during their torpid ſtate, the blood is either ſtagnant altogether, or moves with ſuch extreme ſlowneſs, that the action of the heart can ſcarcely be detected: on the contrary, in ſummer, when the animal is attaining the final cauſe of its exiſtence, and is diſplaying the various actions which it is capable of performing, we find the motion of the blood progreſſively accelerated.

And finally, as we aſcend to the higher order of animated beings, to quadrupeds, and eſpecially to the human ſpecies, we find that the extent of brain and nervous ſyſtem they poſſeſs, and the different actions evidently ariſing from them, are ſuch as demand a regular and conſtant ſupply of blood; ſo that the actions of the different organs become ſuſpended, or irretrievably aboliſhed, if they are deprived of it for a very ſhort time alone. We frequently behold the deleterious effects that are produced in the ſyſtem, by the ſubtraction of a proper ſupply of blood, in conſequence of hæmorrhage, in producing ſyncope, and the ſuſpenſion of animation itſelf. It is impoſſible for me to ſay how long the different organs of the human frame may be deprived of a proper ſupply of blood, and ſtill preſerve their prediſpoſition to action. We are however certain, that not only action, but the prediſpoſition itſelf to it, are entirely aboliſhed, if the motion of the blood be long ſuſpended;—ſuſpended a much ſhorter time in the human ſpecies than in quadtupeds, in quadrupeds than in the amphibia, and in theſe than in vegetables.

I cannot ſtate preciſely, how faſt the ſap of vegetables moves; and however true it may be, that in vines it moves at times with conſiderable velocity, we muſt conclude, that in general the motion of the ſap is very ſlow: in fiſh, the heart contracts about thirty times in one minute; in the amphibia, between thirty and forty; in quadrupeds, between forty and fifty; and in the human ſpecies, between ſixty and eighty*.

That the motion of the blood is wholly dependent on the wants of the ſyſtem, in conſequence of the action it performs, will be evident by comparing and contraſting the action of the heart, during the ſtate of ſleep, with that of watchfulneſs,—of languor and torpor, with that of ratiocination and action. In the former caſe we find the motion of the blood much ſlower than in the latter, more eſpecially if it be accompanied by muſcular exertion in the production of voluntary actions. It is thus we find that the action of the heart becomes conſiderably increaſed, the motion of the blood accelerated, in conſequence of the waſte which the different parts of the ſyſtem ſuſtain. Whilſt the motion of the blood in the robuſt of body and calm in mind is ſlow; on the contrary, we find in the weak and irritable it is generally very quick. Let us only reflect on the palpitation of a nervous lady, and the immenſe velocity with which the blood is moved.

---

* Although ſuch are the degrees of contraction in theſe different ſyſtems in general, no doubt can exiſt but that there are various exceptions alſo. It is however commonly found that in ſmall animals the blood moves quicker than in large: thus it is that in a dog it often beats 80 and upwards, whilſt the pulſe in a horſe is from 35 to 45 in a minute.

This principle is further proved, by examining the motion of the blood in the various acute diſeaſes with which the human frame is ſo frequently attacked, where the waſte of the ſyſtem is very conſiderable, as is proved by the emaciation which takes place, in fevers, inflammations, &c. &c. It is thus we behold the pulſe accelerated to an enormous degree, increaſing from 60 or 70, to 120 or 150; and we frequently feel it beat ſo quickly, that we cannot diſcriminate the interval between each ſtroke. Theſe are caſes that indicate extreme weakneſs, that prove the irritability of the ſyſtem when deſtitute of power, the inability of the vaſcular ſyſtem by which it is to be conveyed to the lungs, where it is to be purified and renewed.

CHAP. XVII.

OF THE DIFFERENT DEGREES OF POWER IN THE RESPIRATORY ORGANS OF DIFFERENT ANIMATED SYSTEMS.

Stronger in man and quadrupeds than in the amphibia or fiſh—the colour of the blood in theſe different ſyſtems—and in different ſyſtems of veſſels, &c. &c.

IF we take a general review of the lungs or ſanguifying organs of different ſyſtems, we ſhall find that there is a progreſſive decreaſe in their extent and power as we proceed from the higher to the lower claſs; and that this variety ſeems principally to be regulated by the complication and ſimplicity of their frame, and the final cauſe which they are ſeverally deſigned to fulfil. Man and quadrupeds have large lungs with ſmall cells: the area of their ſurface becomes conſequently increaſed, and a large quantity of air is acted upon and ſeparated in a ſhort time. Animals of this claſs therefore breathe often, generally four times in one minute. As we proceed from this order to the next, as the turtle, frog, and newt, &c. we find their lungs particularly characteriſed by the largeneſs of their cells; ſo that the area of their ſurface becomes conſequently diminiſhed. Leſs air therefore can be immediately applied to the ſurface of the bronchia;—a leſs quantity is conſequently digeſted and abſorbed,—more therefore remains. Such is the living and preſervative power of the amphibious claſs that, notwithſtanding the extent of the pulmonary ſurface is ſmall, they receive as much air during one inſpiration as is ſufficient to ſupply the want which the blood demands for a conſiderable time. Hence it is that they are capable of remaining long under the ſurface of the water.

As we proceed from animals having large lungs with ſmall cells, to thoſe that have ſmall lungs with large cells, we arrive at the true amphibious claſs,—to thoſe that have lungs and gills, as the ſyren. When the nervous energy of this animal is exerted and diſplayed in the medium of air, the increaſed waſte which the blood conſequently undergoes, produces the neceſſity that the lungs ſhould act, and ſeparate pure air from the atmoſphere, by means of which the blood receives a proportionate amendment correſpondent to the waſte. On the contrary, when it lives merely in water, its nervous energy is greatly diminiſhed, exiſting in a comparatively torpid ſtate. The gills are for the moſt part ſufficient to ſeparate as much air from the water as is neceſſary for the melioration of the blood.

The reſpiratory organs progreſſively decreaſe in power as we deſcend in the great ſcale of animated exiſtence. As we proceed from the true amphibia that have lungs and gills, to fiſh that have (branchiæ) gills alone, if the extent of their ſurface be examined with relation to the element in which they reſide, we ſhall be led to conclude, that the quantity of air which is abſorbed is comparatively very ſmall; ſo that the blood in its circuit through them has not derived, becauſe its does not require it, the ſame degree of melioration as the other *.

Finally,

---

* It muſt not however be ſuppoſed, that amphibious animals are able to live altogether in water; they are obliged to riſe frequently on the ſurface for the purpoſe of

Finally, if we proceed to the loweſt orders of inſects, and of the whole vegetable kingdom, where the blood for the moſt part moves without circulating, we ſhall at once be aſtoniſhed to behold the wonderful preſervative properties they poſſeſs. Each part is not dependent for its ſubſiſtence on particular organs, as in the higher ſpecies I have deſcribed; but every part poſſeſſes organs of

---

of reſpiration. They may be ſuffocated and drowned in common with the moſt perfect quadruped; there will be a difference in time, but the end will certainly be the ſame. Fiſh in general are indigent of the ſame element, although in an inferior degree: fiſh may be drowned as perfectly as either the amphibia or quadrupeds. Carp and tench frequently fall victims to the want of air, when the ſeverity of the winter's froſt has covered with ice the ſurface of the pond in which they reſide, and excluded from it the regular ſupply of air. The fact has been proved by various experiments alſo. When fiſh have been placed either in diſtilled water, or in water the air of which had been exhauſted by the power of the air pump; in every caſe the fiſh languiſhed and died.

Theſe facts prove in a very decided manner, that branchiæ act upon the air (uncombined with the water) which the water contains; and that they do not ſeparate and decompoſe the water itſelf into the conſtituent parts of air—oxygene and hydrogene—by the union of which it is ſuppoſed to be conſtituted.

its own by means of which it can nouriſh and ſupport itſelf. Thus it is that different inſects have air veſſels that continually abſorb air, not partially, but generally; not by the medium of one organ alone, but from every point. In ſome theſe air veſſels ariſe from within, and digeſt the air they receive through the medium of the mouth; in others, theſe air veſſels ariſe from the whole external ſurface, and perform the ſame office. It is more eſpecially the caſe with vegetables. Such are the preſervative properties that each part in theſe poſſeſſes, that it may be cut and ſeparated from the ſyſtem to which it belonged, and ſtill preſerve for a conſiderable time the power of life and of action.

Of the Colour of the Blood which different Syſtems contain.

Although the medulla of vegetables and the blood of the lower order of animals move in a very ſlow and imperceptible manner with relation to the blood in beings of an higher claſs, we notwithſtanding find, that it is moſt eminently fitted to anſwer the uſe to which it is ſubſervient, in a degree far ſuperior to thoſe higher ſyſtems in which it moves more rapidly, and where we find a great and ſtriking difference in the colour and temperature it aſſumes in different veſſels. The medulla of vegetables and the blood of inſects for the moſt part are white, bordering on a yellow caſt. The blood of fiſh contains a very large proportion of craſſamentum, and a ſmaller one of ſerum than inſects. The blood of the amphibia is more florid than that of fiſh and of inſects, and the quantity of ſerum is leſs. It not only is more florid, but there is ſome variety in its colour as it exiſts in different ſyſtems of veſſels. It is more florid as it proceeds from the lungs, than it is as it returns to them. As it returns to them, it is of a more purpliſh die: the difference is not very ſtriking, but it may be eaſily diſcovered*.

If, however, we examine the difference of colour in the blood of quadrupeds in general, and of the human ſpecies in particular, it is not of a deeper red in the aggregate than the blood of the amphibia, of fiſh, of inſects, or the medulla of vegetables: but there is a total difference alſo in the colour it aſſumes as it proceeds from the lungs through the medium of the pulmonary veins to the left ſide of the heart, from what it is found to be as it returns back to the lungs through the medium of the right ſide of the heart and pulmonary artery.

---

* When the amphibia are either in a languid or in a torpid ſtate, the colour of the blood progreſſively increaſes, and frequently becomes almoſt black, and nearly coagulated. We are however to take this as a condition of diſeaſe, not an healthy condition.

As the blood proceeds from the lungs, we have ſeen it to be florid and fluid: ſuch however is the immenſe waſte which it ſuſtains of the pureſt parts of the whole from the exhalant outlets of the arteries, in the ſupply it affords to the different ſecretory organs, that the veins return only the refuſe of the whole maſs, which abounds with craſſamentum, and which is deprived of a large proportion of ſerum, that is black inſtead of being florid, that is perpetually diſpoſed to coagulate inſtead of preſerving its fluidity. Theſe morbid changes which the blood undergoes in its circuit through the ſyſtem, progreſſively increaſe in degree in proportion as it proceeds fartheſt from the lungs, as the organ by which it was meliorated. Hence it is, that the blood exiſts in its higheſt ſtate of perfection, as it immediately departs from the lungs, and in its worſt ſtate as it is returned to them; more perfect in the large arteries before the waſte is produced, than in the ſmaller ones upon the ſurface; more in its return by the ſmall veins than in the larger; more perfect in the vena ſaphena than in the cava; and finally, leſs imperfect in the cava than in the pulmonary artery. When the blood arrives in the pulmonary artery, it is of a black and of a purpliſh colour, having a conſtant tendency to coagulate, and abounding with gazeous and azotic matter, in its nature deleterious and deſtructive to the ſyſtem in which it is generated and contained.

It has been generally ſuppoſed, that the extrication of fixed air is the cauſe of the black colour which the blood ultimately aſſumes. That this however is not the caſe, is proved from hence, that when florid blood is expoſed to a volume of fixed air in a cloſe veſſel, it does not become black. Dr. Goodwin introduced four ounces of florid blood, freſh drawn, into a glaſs receiver containing fixed air, and confined it there for a conſiderable time; but it neither became black, nor underwent any ſenſible change. He then received ſome florid blood from the carotid artery of a ſheep into a phial filled with fixed air, but ſtill the florid colour was not altered. The change of colour, therefore, which the blood aſſumes does not ariſe from the retention or even extrication of fixed air, It is proved in the moſt decided manner by the white colour which the blood perpetually aſſumes in the lower order of animals, eſpecially of inſects, that are continually immerſed in entire volumes of fixed air and of nitrogene, and who feed principally upon them; and yet their blood, inſtead of being black, is white altogether. It is eſpecially the caſe with the medulla of vegetables, that is principally elaborated and formed out of the ſame ſubſtances.

Mr. Bell naturally obſerves, that he does not, and that he cannot account for the action of theſe airs in producing whiteneſs in the blood of theſe animals, whilſt the blood of the human ſpecies becomes black in proportion as it becomes carbonated. He therefore confeſſes, that theſe facts confound his knowledge. He might have added, that ſuch confounded knowledge becomes knowledge confounded by the very facts which he has adduced.

So far from the fact being true, that our blood becomes black by becoming carbonated, it appears, that it is by the extrication and loſs of carbonic air, not by the retention of it, that the blackneſs is produced. It proceeds from the carbonic air becoming decompoſed, and paſſing from a latent to a ſenſible ſtate; from a ſtate of union with the other conſtituent parts of the blood, to a ſtate of decompoſition and ſeparation from them, to the total expulſion from the ſyſtem itſelf, which conſtitutes the cauſe for the black colour which the blood aſſumes. It is very true, that the union of oxygene will make black blood become red: but it does not appear that it depends on carbonic air that red blood is made to become black. On the contrary, it ſeems principally to ariſe from the ſtate of deterioration which it undergoes, and which, we have already ſtated, proceeds from the injury it ſuſtains by the operations of the ſyſtem to which it is ſubſervient. That blood is ſpontaneouſly diſpoſed to undergo this morbid alteration, is proved by facts innumerable, when merely deprived of the melioration alſo which it demands. If it be placed under the exhauſted receiver of an air-pump, it very rapidly changes from a red to a black colour. If its return to the lungs be delayed by the dilatation and weakneſs of varicoſe veins; if it be extravaſated in an aneuriſmal ſac, or in the cellular membrane, we find it undergoes the ſame alteration. It is from the ſame cauſe that the purpliſh colour in the face is produced by a violent coughing, as in the hooping-cough, by long continued expirations, whether it be in the act of ſneezing, crying, or produced by violence, as from ſtrangulation itſelf.

That mere reſidence will change blood from a red to a black colour, is proved from a variety of facts. Mr. Hunter tied the carotid artery of a dog, and ſome time after punctured it; the blood that flowed was perfectly black. And in the ordinary caſes of phlebotomy, when the arm has been tied for ſome time, the firſt blood that flows is generally blacker than that portion which has been more recently purified by the lungs.

This natural tendency of the blood to decompoſition and decay, may be accelerated by various means, more eſpecially by the operation of various animal and vegetable poiſons.

L'Abbé Fontana amuſed himſelf with the occupation of poiſoning different ſpecies of animals with different kinds of poiſon. In every caſe he found, that the blood changed from a red to a black colour; and that its power of preſervation which the animal poſſeſſed was immediately loſt, ſo that it very ſpeedily underwent the proceſs of putrefaction and decompoſition. "I let fall," ſays he, "in a conical glaſs three drops of the venom of the viper, and twenty drops of blood that iſſued from the neck of a fowl into which I had made an inciſion. I reclined the glaſs, ſhook it circularly for ten ſeconds, that the venom and the blood might mix together. At the ſame time, I let fall into a ſimilar glaſs twenty drops of blood of the ſame fowl, in the ſame ſtate as the laſt, and ſhook the glaſs in the ſame way as the laſt. At the expiration of two minutes; the blood unmixed with the venom coagulated, and was of a fine vermilion colour. On the contrary, the blood united with the venom was black and fluid." The ſame experiment was tried with the blood of a guinea pig, with the ſame reſult. The venomed blood did not harden, but dried by degrees, ſplit into ſcales, and preſerved its blackneſs: the other continued red. The ſame effects take place by the introduction of vegetable poiſons, as the napel, and more eſpecially of the ticunas; the poiſon which the American Indians employ to arm their arrows. Fontana put four drops of an aqueous ſolution, which could ſcarcely contain half a grain of the dried poiſon, and introduced it by means of a ſyringe into the jugular vein of a large rabbit; and although a very ſmall portion of the liquor was received by the animal, it died inſtantaneouſly. Another rabbit was killed by half a drop of this poiſon. The blood in the veſſels was much darker, and the lungs full of ſphacelated ſpots*.

---

* He applied the ticunas to different tendons, and to the nerve itſelf; but it did not appear to have the ſame morbid effect upon them as upon the blood.

CHAP. XVIII.

OF ANIMAL HEAT.

Produced and increaſed by the actions of the ſyſtem—black blood therefore is hotter than florid, in the pulmonary artery than in the pulmonary veins—proved by experiment—that animal heat is cauſed by animal action is further proved from the evolution of ſenſible heat at different periods of life, in different diſeaſes, and in different orders of animated beings—their temperature examined and compared, &c. &c.

IT is not by theſe morbid changes alone of blackneſs and of ſolidity which the blood aſſumes, as it returns to the lungs, that it is characteriſed and diſtinguiſhed from the pure ſtate of the blood at its ſource, as it proceeds from the lungs. It is eſpecially diſtinguiſhed by the high and increaſed degree of temperature which it progreſſively obtains.

It appears from experiments, which I ſhall preſently relate, that in proportion as the blood changes from a pure and a healthy ſtate, to an impure and a diſeaſed one; in proportion as the florid colour of the blood decreaſes, and the black colour increaſes, that there is a progreſſive increaſe of ſenſible heat, ſo that the blood in the right ſide of the heart is much hotter than the blood on the left.

That this is a fact, has been proved by various experiments made by Mr. Aſhley Cooper and Mr. Colman.

Exper. 1. A dog was hanged and the ſternum removed, and the lungs inflated until the blood in the left auricle became florid. The contraction of the whole heart at this time was powerful. Mr. Hunter's thermometer, being raiſed to 98, was introduced through an opening made in the pericardium, and placed on the right ſide. The mercury roſe to 99, and then became ſtationary. The thermometer was then removed to the left ſide of the heart, but the temperature was the ſame. Thus it appeared, that the heat within the pericardium on the internal ſurface of both ſides of the heart was uniform.

Exper. 2. An aperture was made in the right ventricle of the heart, and the bulb of the thermometer thruſt into it. The mercury fell from 99, to which it had riſen in the pericardium,

ricardium, to 98. On applying the thermometer to the left ventricle, it fell to 97.

Exper. 3. The ſame experiment was made upon a cat. The temperature in the pericardium on both ſides of the heart was 98. On thruſting the thermometer in the right ventricle, the mercury roſe to 99; but when applied to the left it fell to 97. Fifteen minutes after, the temperature of the ſame blood was re-examined. Inſtead of the blood which the right ventricle contained preſerving two degrees of heat more than the blood which was in the left; it was found, on the contrary, that the blood from the right ventricle was four degrees lower than the blood which was obtained from the left. Mr. Cooper has aſſured me that he has made the experiment in different ways; and he has invariably found, that although the blood that returned to the lungs was of ſuperior temperature at firſt, to the blood that proceeded from them; yet that before coagulation was complete, a conſiderable evolution of heat took place; that the arterial blood then became from three to ſix degrees warmer than the venous.

That the production of animal heat proceeds from the decompoſition of animal matter, is proved by examining the various circumſtances under which the reſtoration or evolution of animal heat more eſpecially takes place; whether the examination be made in a ſtate of infancy, of manhood, or of old age; of health and of ſtrength, of weakneſs, and of diſeaſe. In the period of infancy, when the living principle is wholly and actively employed in the evolution of the ſyſtem, when the growth is great and the waſte comparatively ſmall, it does not appear that the blood ſuffers the ſame degree of deterioration as it is found to do when the various energies of the mind are eminently diſplayed in the ſeveral faculties of reflection, and in the production of muſcular and voluntary motion. The living power, therefore, which the whole of the blood contains, preſerves its ſeveral parts in a ſtate of union. The decompoſition that enſues is conſequently ſmall; ſo that the temperature of the external ſurface is very low, and for the moſt part is regulated by the ſtate of the atmoſphere.

This is the true condition of the infant in a ſtate of health, when the living principle is employed in the evolution of the ſyſtem in the proceſs of organization alone.

It is far otherwiſe in a ſtate of diſeaſe. When the living principle cannot organize or preſerve what it has produced, decompoſition then takes place, a waſting of the ſyſtem enſues, and a general evolution of heat. It is then that we behold a burning ſkin, a florid ſurface. The caloric, inſtead of continuing latent, by preſerving the living power the lungs had imparted to it, becomes ſenſible, when that living power is loſt by the effect of decompoſition and diſeaſe. At the period of manhood, when the evolution of the ſyſtem is complete, and when the lungs are comparatively ſmall to the magnitude of the ſyſtem in general, the degree of warmth is proportionably higher than in infancy; when the ſyſtem is proportionably ſmall and the lungs large, and the blood in the pulmonary artery is much higher than the blood in the pulmonary vein. At that middle period of life the ſpecific actions of the different organs are then in full energy, and the waſte the blood ſuſtains is conſequently very great. It is more eſpecially the caſe from the exertion of the mind; and it is moſt probable that the brain ſeparates a quantity of caloric from the blood, which conſtitutes the nervous fluid; and that the loſs which the blood conſequently ſuſtains, is the cauſe of the weakneſs and laſſitude which the body feels by the exertion of the mind.

At the period of old age, when the ſpecific action of the organs of ſenſation and of voluntary motion is weak and exhauſted, and when the living principle is only employed in preſerving what it has produced, the waſte of the ſyſtem is ſmall. The temperature therefore is comparatively low.

This is the condition of the ſkin at the ſeveral periods of manhood and of old age. When the ſyſtem is in a ſtate of health and of ſtrength, ſo long as the different parts perform their functions in an eaſy and regular manner, the reſpiration is eaſy, the motion of the blood comparatively ſlow, and the temperature of the external ſurface of the body much below the ſtandard heat of the internal parts.

On the contrary, when diſeaſe takes place, ſuch as fevers, inflammations, &c. &c. the reſpiration is laborious, the blood is moved with increaſed velocity, the temperature of the external parts is conſiderably increaſed by the evolution of heat which takes place, and a general waſting of the ſyſtem conſequently enſues. The evolution of heat which then takes place proceeds from the deprivation of living power which the blood ſuſtains in conſequence of the waſte it undergoes by the action of the ſyſtem at large; a chemical union therefore between its conſtituent parts is produced, and an increaſed quantity of heat is generated.

The evolution of heat is alſo augmented in conſequence of increaſed actions either of body or of mind, and eſpecially of both together. Hence ariſes the univerſal ſenſation of heat from a fit of paſſion, from exceſs of exerciſe. This increaſed evolution of heat proceeds in an eſpecial manner from thoſe parts of the ſyſtem which are moſt abundantly ſupplied with nerves, and that are more immediately deſtined to diſplay the conſciouſneſs or the energy of the mind. Thus a glow and warmth on the cheeks from the conſciouſneſs of merit openly rewarded, or from the baſe ſenſation of ſhame, in conſequence of a conduct turpid or bad; the warmth of the lips from the prurience of the imagination, &c. &c. &c. Theſe various actions have a conſtant tendency to weaken the bond by which the parts are held together, and to produce their decompoſition.

That this is the fact, will be further apparent by taking up the converſe of the caſe, and by examining the effects that enſue when thoſe ſeveral actions have ceaſed. Thus it is, that in the laſt ſtages of the moſt putrid diſeaſes, when the pulſe is too quick to be meaſured, the ſkin is too hot to be touched without imparting the ſenſation of burning heat, and the excretions are found to be nauſeous and putrid. As ſoon as thoſe actions have ceaſed, either by the cure or the death of the patient, the various phenomena I have juſt deſcribed evidently ceaſe; and a perſon who was ſtinking and putrid whilſt alive, in conſequence of the decompoſition which the different parts underwent from the action of diſeaſe, has the ſtate of decompoſition evidently arreſted as ſoon as thoſe actions have ceaſed*.

On the contrary, in torpid habits more eſpecially,

---

* It is by contemplating the functions of the ſyſtem in this point of view, that we are confirmed in our opinion, and are enabled to ſee how the ſpecific actions of the organs in particular have a conſtant tendency to exhauſt the

cially, as we behold in the ſcrophulous and chlorotic, when the ſyſtem does not undergo that degree of change which is abſolutely neceſſary for the preſervation of health; when there is little renovation or waſte; the temperature of theſe is generally very low, and is in them the proximate cauſe of different local and general complaints. It is owing to the abſolute neceſſity that exiſts in the higher order of animals for a conſtant renovation and change of parts, that they become more indigent than thoſe of a more ſubordinate kind; that whilſt their circulation is more rapid, and their temperature high, in the other it is for the moſt part ſlow, and the temperature comparatively low.

If we examine the temperature of vegetables and of the moſt ſimple order of animals, we ſhall find that it principally depends on the quality of the medium in which they are deſtined to reſide. Although the degree of warmth (ſenſible heat) they poſſeſs is relatively low,

---

the ſtrength and living power of the ſyſtem in general, and more eſpecially thoſe actions that flow from the operation of the mind, which have, as I ſaid before, a conſtant tendency to weaken or altogether to deſtroy the living and preſervative powers of the body. How often do we not hear of ſudden death from violent fits of paſſion, &c.

their living power is very high, ſo that the living power of what are called cold-blooded animals far ſurpaſſes that of the warm.—In proportion as the ſimplicity and ſelf-ſufficiency of theſe ſeveral ſyſtems decreaſe, there is a progreſſive increaſe of temperature; from fiſh to the amphibia, and from amphibia to the moſt complicated animals. The temperature of fiſh that have branchiæ, and a heart with two cavities only, is for the moſt part ſtationary, depending on the degree of temperature of the medium. If we proceed from fiſh to the amphibia, that have lungs with large cells, a heart with three cavities (or rather four cavities imperfectly formed), we find the temperature progreſſively increaſes, and that this degree principally depends on the magnitude of the bronchiæ, or organs by which the blood is purified from the increaſed waſte it undergoes. In a toad, when the temperature of the atmoſphere was at 36 of Fahrenheit, the temperature of the animal's ſtomach, and under the ſkin of the belly, was at 40. In a frog, when the atmoſphere was at 35, the temperature of its ſtomach and belly was 39 to 40. In a turtle, it is about 42. On the contrary, in quadrupeds, and the human ſpecies, that have lungs with ſmall cells,—that have a heart with four diſtinct cavities, and where the waſte of the ſyſtem is conſiderable in conſequence of the various actions they perform; their blood, as I have ſaid before, at its ſource, when ſubſiſting in its pureſt ſtate, is 97; at its termination, and in its moſt impure one, it is 99.

The blood which the pulmonary veins, left ſide of the heart, and arterial ſyſtem contain, is for the moſt part fluid; and although it is two degrees cooler than venous blood, ſo long as the powers of life and of action continue,—this cool arterial blood, by the ceſſation of vital action, becomes ſenſibly warmer than the venous, and raiſes the mercury in the thermometer higher than the other. When the venous blood is coagulated, it is combuſtion ended with a low temperature;—with the arterial, it is combuſtion begun and actually exiſting with the temperature high. After this effect is ended, and the decompoſition produced that muſt neceſſarily attend, the arterial blood loſes this high degree of temperature, and ſinks down to the ſame level as the venous is found to attain out of the ſyſtem, after it is coagulated.

If the cauſe of animal heat depended, as is generally ſuppoſed, on the quantity of caloric that is abſorbed, the temperature of the ſyſtem at the period of manhood would be far lower than it is found to be during the period of infancy, becauſe the comparative magnitude of the lungs in particular, with reſpect to the ſize of the ſyſtem altogether, is much leſs in the one than it is in the other. In infancy, the lungs have attained their fullneſs of growth, when the ſyſtem is not half evolved. Great therefore muſt be the quantity of caloric ſeparated and abſorbed. How immenſely high then ought to be the temperature of the infant frame! And finally, that animal heat does not altogether depend on the quantity of caloric which is abſorbed by the lungs, is further proved by facts which every practitioner muſt often have beheld—Of the continued and exceſſive quantities of ſenſible heat which are evolved from different patients labouring under phthiſis pulmonalis, at thoſe times, when the diſeaſe of the lungs muſt weaken, or altogether bereave them of the power of acting. I have ſeen a ſcorching and a burning heat iſſue from the ſurface of the ſkin of thoſe, whoſe lungs, after death, I have found eroded and almoſt totally waſted, the bronchiæ themſelves plugged up and abounding with purulent matter, and when the quantity of caloric abſorbed muſt conſequently have been very ſmall. So far indeed is the abſorption of caloric from producing heat in the part by which it is received, that it tends to abate the temperature of the blood. It produces, it is true, an increaſe of fluidity and a melioration of colour. It changes blood from a coagulating or ropy conſiſtence to a fluid one,—from a black to a florid colour, and from a higher degree of heat to a lower one.

If the lungs were the immediate agents by which animal heat was produced, and the production of *animal warmth* the final cauſe of their action, the effects would be immediately rendered ſenſible by the temperature of the blood by which that warmth was received; ſo that the blood of the pulmonary veins, inſtead of being cooler, would be much hotter than the blood in the pulmonary artery. We may therefore conclude that the atmoſpheric matter which the blood immediately receives through the medium of the lungs, does not act by the production of ſenſible heat (of warmth), but by meliorating the quality of the blood, eſpecially with reſpect to fluidity and colour,—conditions of the blood which are known to be moſt favourable for its uſe.

That the lungs are not the immediate ſources of animal heat, is further proved from the low temperature of the blood of thoſe who inſpired air of a degree of temperature far exceeding the heat of the blood*.

Although the air of the room was heated to 212, and even up to 260 degrees,—inſtead of this air ſo heated being received by the blood in that ſtate, the blood continued at the ordinary temperature of 99 and 100. The lungs therefore had the power of decompoſing the ſenſible heat, and of abating the high temperature it contained.

Seeing then that the ſenſible heat of the blood abates, whilſt the lungs perform their functions in a proper manner in meliorating the blood ; and on the contrary, that the ſenſible heat of the blood progreſſively increaſes in proportion as it proceeds fartheſt from the lungs dependent on the degree of deterioration which the blood undergoes; I am neceſſarily led to conclude, that the generation of high degrees of ſenſible heat proceeds from the loſs of vitality which the blood originally contained, ſo that a chemical union between its conſtituent parts conſequently takes place.

---

* Vide the experiments of Sir Charles Blagden, Dr. Fordyce, Dr. Hunter, &c. &c.

Such is the high degree of vitality which the blood contains at its ſource in the pulmonary veins, that the whole is in a ſtate of union and concert. It is then that its ſtandard of perfection is to be taken, not only in point of colour and conſiſtence, but of temperature alſo. It is at the termination of the pulmonary artery, after it has ſuſtained the waſte in its circuit through the ſyſtem, that the ſtandard of its imperfection is to be meaſured. Inſtead of being florid and fluid, and its temperature low, it is black, having a conſtant diſpoſition to coagulate, and its temperature is high. I ſay, that as it departs from the organ by which it was meliorated, in that proportion does it loſe its living property, and obtain its chemical: it is by the loſs of the one that it acquires the other. Animal heat would therefore appear to ariſe from a ſtate of decompoſition which takes place between the dying parts of a living animal; and the decompoſition which the blood has ſuſtained, is the cauſe why there are two degrees of difference in the temperature of the good and of the bad blood,—between that which proceeds from the lungs, and that which returns to it; between that which is florid and fluid, and that which is black and which has a tendency to coagulate.

It therefore remains for me to point out the means which the ſyſtem contains, through the agency of which it is capable of extricating and of parting with all this carbonaceous and volcanic matter, with all the charcoal, the fixed and inflammable air, that are produced, which being deleterious to the ſyſtem are conſequently deſtined to be expelled out of it. I am therefore led to deſcribe,

1ſt. The kidneys, and the nature of the urine they ſecrete. 2dly. The exhalant veſſels of the ſkin, and the matter of perſpiration. 3dly. The matter which the exhalant terminations of the pulmonary arteries give out during the proceſs of expiration*.

It was my intention to have given an analyſis of Dr. Crawford's theory of animal heat, and a criticiſm upon it. But as this theory is now quite out of faſhion, and rendered in fact obſolete, by the ſhock which the phlogiſtic doctrine has ſuſtained, I ſhall merely give Mr. Bell's opinion upon it, as the moſt modern writer upon the ſubject, and ſpare the reader the trouble of reading what I have ſaid to prove it improbable, impoſſible, and erroneous.

---

* The diſcharge from the inteſtinal canal is not ſo much an excretion of the ſyſtem itſelf from within, as of matter that has been received from without, and which in ſome reſpect is foreign to the ſyſtem.

" But concerning this doctrine, which in its philoſophical as well as its chemical part is now antiquated, it is allowable to ſay, more freely than of almoſt any other, that its intricacies are its beauties; that it is an hypotheſis illuſtrated by experiments, which have no other tendency than *to make it look well in the face*; and which are made with ſuch affectation of niceneſs as is completely ludicrous. The author pretends to meaſure, to the tenth part of a degree, the proportion of heat in wheat, barley, fleſh, milk, &c. Airs he alſo meaſures, ſhewing the various capacities for heat in the different kinds of air to the tenth part of a degree; a thing much fitter for a magician than a philoſopher to undertake; and which Dr. Crawford has executed ſo ill, that we are teaſed, or rather thoroughly exhauſted, before we begin, with correcting meaſures and inſtruments, and ſettling data; while each new edition of the book on Animal Heat muſt be prefaced with new apologies, new confeſſions, new corrections, new calculations, unhinging ſo entirely the concluſions and calculations of former copies of it, that we find ourſelves even now engaged, along with our inſtructor, in a wilderneſs of errors, from which we can have no hopes of being extricated.

" Oxydation is a proceſs which had no place in Dr. Crawford's views. He never conceived that it was the preſence of oxygene, as a new principle, which gave colour, ſtimulant powers, coagulability, and all its moſt uſeful properties to the blood; but he believed that pure air, uniting with inflammable air in the lungs, formed fixed air; and this fixed air being incapable of containing the heat which it had while in the ſtate of pure air, that heat was depoſited, or, as it were, precipitated upon the blood. He maintains that there are of inflammable air two kinds; one capable of forming water, another of forming fixed air. But fixed air, derived from inflammable gas of any kind, all chemiſts will deny. He begins his doctrine, therefore, not with a fact, but with a petitio principii; and what is worſe, his main experiment is wrong." Page 120, of 2d vol. of John Bell's Anatomy.

Of the Excretory Organs in general—Of the Kidneys in particular.

The kidneys are two in number, ſituated on each ſide of the lumbar vertebræ, upon the poſterior part of the two inferior ribs. The right kidney is placed under the great lobe of the liver: on the contrary, the left lies below the ſpleen, and is rather higher than the right. In ſhape, the kidneys reſemble a kidney bean. Their internal organization aſſumes different forms: the external portion, which is pale, is called the cortical part; the portion of the kidney internal to this is called the medullary; the blood which is conveyed to theſe organs through the medium of the emulgent arteries ramifies in the cortical, and teminates in the medullary portion. The medullary portion, which is found to be of a ſtriated form, terminates in the papillary part of the kidneys, and which ſeems to be the point where the blood becomes altered, and out of it urine produced.

There are ſeveral ſmall apertures, ten or twelve in number, through which the fluid paſſes into a cavity called the pelvis of the kidney.

It is from the pelvis of the kidney that a number of tubes ariſe called tubuli urinarii. Theſe tubes unite into one, and this one tube it is which is called the ureter.

The *ureters* are generally the breadth of a gooſe-quill, and about one foot in height. They have an external covering from the peritonæum, a middle muſcular coat, and an internal mucous one. They paſs obliquely between the coats of which the bladder of urine is compoſed, and finally terminate within its internal ſurface. By this mode of conſtruction it is that a valvular effect is produced; and whilſt the urine is allowed to flow through, it is prevented from returning.

The Bladder of Urine

Is ſituated in the lower and anterior part of the pelvis. It has the ſame coats which we have ſeen the inteſtinal canal poſſeſs, and the ſphincter veſicæ ſeems to be formed in the ſame manner,

ner, and allotted to perform the ſame office as the ſphincter ani.

The bladder is the reſervoir which is deſtined to receive the urine which the kidneys may have ſecreted, until the accumulation is ſo conſiderable, that either from quantity or quality, either from the irritation cauſed by diſtenſion or acrimony, the muſcular coat of the bladder is excited to contract; the ſphincter muſcle gives way, and the urine is expelled through the medium of the urethra out of the ſyſtem as excrementitious and foreign. Such is the deleterious quality of the matter which the kidneys ſeparate from the blood which they receive, that although thoſe ſubſtances were in a latent ſtate whilſt they exiſted in the blood, as ſoon as they have been ſeparated from it by the power of the kidneys, they loſe thoſe latent properties which they contained by the living power which they had received, and become immediately ſenſible. Thus it is that cantharides, either when abſorbed by the ſkin from the application of a bliſter, or introduced into the ſtomach in the form of medicine, and conveyed into the maſs of blood,—although they do not then produce any ſenſible effects, as ſoon as they become ſeparated by the kidneys from the blood, the ſenſible properties which had been deſtroyed, and become latent, by the power of the aſſimilating organs are again recovered. The cantharides act by virtue of their ſenſible qualities; inflame either the kidneys, the ureters, but more eſpecially the neck of the bladder of urine,—that portion of it which is the moſt irritable of the whole, producing thereby ſtrangury. It is owing to this ſtate of decompoſition which the conſtituent parts of the blood ſuſtain, which the kidneys receive, and the deleterious qualities which are imparted to them by the power of the kidneys, that we can frequently detect them in the urine. Thus it is that nitre, when taken by the ſtomach, is frequently found in the urine in ſo pure a ſtate that touch-paper may be formed; that the urine gives out particular ſubſtances which impart particular ſenſations to the olfactory or optic ſenſes, as turpentine, aſparagus, rhubarb, indigo, &c.

It is owing to the decompoſition which the urine undergoes, that we ſee it ſo prone to cryſtallize. This ſtate of decompoſition often takes place within the pelvis of the kidney itſelf, and gravel and calculi are formed in it. I have ſeen ſome kidneys completely filled by large ſtones, that had acquired the uſual ſize of the kidney itſelf. This tendency to decompoſition progreſſively increaſes as the urine departs from the kidneys; it becomes acrid by long reſidence in the bladder; the quantity of ſaline matter it contains recovers its chemical qualities. The quantity of ſerum in which theſe chemical bodies are involved, preſerves them in a ſtate of ſolution, but by long reſidence the ſerum itſelf loſes in part this ſolvent power. The ſaline matter becomes precipitated, like a ſaturated ſolution of ſugar or of ſalt in hot water, when it is expoſed to a cold medium. I do not mean that the temperature of the ſerum is lower, but that its ſolvent power becomes weakened; that it is unable to keep ſuſpended the ſame quantity of ſaline or other extraneous matter, after it has remained a conſiderable time in the bladder, that it did ſoon after it arrived there. It is owing to this cauſe that gravel and calculi are ſo frequently found in the bladder, and that the urine itſelf, although perfectly clear and apparently homogeneous at the time it is voided, is found ſoon after to ſeparate and decompoſe, to depoſit ſediments of different kinds. This is more eſpecially the caſe with the weak and ſickly than with the ſtrong and healthy,—with the old than the young. The urine of the old, indeed, is generally clouded and gritty, acrid and ſtimulating, weakening by conſtant action the ſphincter muſcle; ſo that the urine is at length voided without any power by which it can be reſtrained.

It is not theſe ſaline ſubſtances alone that are ſeparated from the blood by the power of the kidneys, and which are involved in the ſerum of the urine ; but we are able to aſcertain, that it contains a large quantity of the phoſphoric or inflammable matter alſo, which I have proved was generated in the ſyſtem itſelf by the actions it performed. That this is the caſe is proved by the analyſis of urine ſoon after it is voided.

Upon the moſt modern and beſt chemical authority, the conſtituent parts of human urine are, phoſphate of lime, phoſphate of ammonia, phoſphate of ſoda, muriate of ſoda, muriate of potaſh, a ſoapy ſubſtance conſiſting of oil, carbonate and muriate of ammonia and a little looſe alkali, beſides a mucilaginous extractive matter, and water.

CHAP. XIX.

ON PERSPIRATION, OR SECOND MODE OF EXCRETION.

1. *The quality of the aëriform matter aſcertained by different experiments—the quantity alſo.*—2. *Quality and quantity of the fluid perſpired, &c. &c.*

THE matter which is perſpired through the exhalant veſſels that terminate on the ſurface of the ſkin conſtitutes the ſecond means by which the blood becomes depurated from a large quantity of noxious matter which it continually generates;—matter either of a ſolid, of a fluid, and more eſpecially of an aëriform ſtate.

It frequently contains various ſubſtances which had been received by the medium of the chylopoietic viſcera into the blood, and which were there latent and inoffenſive, but are afterwards given out in a ſenſible form. The odour which the perſpirable matter imparts to the olfactory ſenſe of thoſe who have eaten onions, or taken mercury, is very perceptible. It is equally the caſe with various poiſons that have been received into the blood, either by the action of the abſorbents from the ſkin, or that were involved in our food. If the aſſimilation has been complete, and the ſenſible properties of theſe ſubſtances totally deſtroyed, they continue in the blood dormant and harmleſs. They may be even depoſited in glands or interſtitial parts, and anſwer the purpoſes of ſecretion or of reſtoration. If, however, the aſſimilation has been imperfect, and more eſpecially if, with this imperfection, exciting cauſes ariſe to weaken the conſtitution in general, and to looſen the bond by which their ſenſible properties were held together;—in ſuch caſes, I ſay, the particular and original properties which theſe ſubſtances poſſeſſed, inſtead of continuing dormant, become ſenſible; inſtead of being in harmony with the whole, they act upon the parts in which they are depoſited, producing the various phenomena of diſeaſe, either univerſal or local, or both. This I take to be the proximate cauſe of many fevers, the ſeeds of which every individual carries about him; and it only requires the application of ſuch cauſes as tend to weaken the ſyſtem, that looſen the bond which keeps theſe ſubſtances in a dormant ſtate, to make them diſplay their ſenſible properties, and excite the phenomena of diſeaſe. It is the caſe alſo with various ſpecific poiſons, as that of ſyphilis and hydrophobia, ſmall-pox and meaſles, &c. &c. &c. Diſeaſe therefore is the very reverſe and oppoſite to health. Health conſiſts in the organs acting upon the blood, and in the blood itſelf, being preſerved in a ſtate of union and conſent. On the contrary, diſeaſe conſiſts in the blood loſing the power by which this union is produced. Decompoſition therefore takes place; and the matter ſo decompoſed, inſtead of being acted upon, acts upon the organs, producing inflammation and diſeaſe. It is in conſequence of this ſtate of decompoſition that various ova and animalculæ, which the blood contained in a latent form, become evolved in a ſenſible one. This is often the caſe in thoſe organs which are particularly ſupplied with the worſt blood, as the liver—where the bond of union is moſt weak, and the diſpoſition to decompoſition is the moſt ſtrong. Hence it is that worms are frequently found in the ſubſtance of the liver itſelf.

It is more eſpecially the caſe when the actions of life have ceaſed, and the aſſimilating powers are loſt, and when a total decompoſition of the ſyſtem enſues: it is then that the ſyſtem becomes a prey to the vermin it contained; that it becomes devoured by the very aliment on which it fed—ſo that the ova which that aliment contained become evolved by the nouriſhment they receive from the ſyſtem of which they formed a part, and for the ſupport of which they were eſpecially deſigned.

The fluid and aëriform matter, &c. which is given out by the veſſels of the ſkin as excrementitious and foreign, has been examined by different phyſiologiſts; but by no one ſo particularly as by Mr. Abernethy and Mr. Cruickſhank. Mr. Abernethy filled a glaſs jar with quickſilver, which was inverted in a trough, containing ſuch a quantity of quickſilver as was ſufficient to allow the introduction of his hand into the jar. By theſe means, the matter emitted from the ſurface of his hand was readily collected on the top of the mercury. In ſixteen hours half an ounce meaſure of air was obtained; no kind of moiſture appeared on the ſurface of the quickſilver, nor could be collected by the introduction of bibulous paper. Whatever moiſture was emitted adhered to the ſurface of the hand, whilſt the air by its levity aſcended to the top. On throwing up lime-water to this air, two-thirds of it were rapidly abſorbed; a proof that it contained ſo much carbonic acid gas, or fixed air. On throwing up to the reſiduum a bubble of nitrous air, no red fumes were abſorbed, nor was there any diminution of quantity; proving it to conſiſt of nitrogenous or phlogiſticated air.

This experiment was varied by ſubſtituting water to the quickſilver in the jar. The water abſorbed the carbonic acid gas, and the phlogiſticated air remained at the top of the water.

Mr. Abernethy expoſed his hand ſucceſſively to atmoſpheric air and to nitrogenous gas; and in every caſe he found the emiſſion of fixable air and of nitrogene.

In the laſt place, he endeavoured to aſcertain the quantity and quality of the ſerous (not aqueous) perſpiration. For this purpoſe he introduced his hand and fore-arm into a jar covered with a bladder: an aperture was made in the bladder to admit the arm, round which the bladder was tied. In ſix hours nearly three drachms of a fluid, limpid and taſteleſs, were procured. On evaporation it appeared ſlightly ſaline. It underwent no change when left to ſtand for ſeveral days, nor altered the colour of vegetable blues, nor precipitated or coagulated when marine acid was dropped on it, or cauſtic alkali.

Mr. Abernethy thinks the quantity of air perſpired in one day amounts to nearly three gallons, and of water about two pounds and an half. He collected in one hour, of water exhaled from the lungs, about three drachms, inſipid, but not limpid. On evaporation a ſlight cruſt remained on the ſurface of the glaſs; not ſalt, but which had a *burnt ſmell.* After ſtanding for a few days, it changed the vegetable blues to a faint green. The evolution of heat which takes place, does not proceed from any ſpot in particular, but iſſues out from the ſurface in general. It is combined for the moſt part with a quantity of noxious matter, which is expelled with it out of the ſyſtem as deleterious and hurtful.

CHAP. XX.

ON EXPIRATION, OR THE THIRD AND LAST MODE OF EXCRETION.

The diaphragm uſeful in expiration only, by diminiſhing the longitudinal capacity of the thorax—is of no ſervice in inſpiration, as ſtated by ſome—in extraordinary caſes the abdominal muſcles co-operate with the diaphragm in depreſſing the ribs, and in producing a more complete diminution in the internal capacity of the thorax—by means of which the azotic air is expelled, as deleterious and foreign—its qualities noxious, and the cauſe of diſeaſes.

SUCH is the ſenſe of uneaſineſs and pain, of oppreſſion and of debility, which is produced by the excretory matter returned into the bronchia by the exhalant termination of the pulmonary arteries, that the functions and actions of the machine would be infallibly aboliſhed, if this excretory matter were retained inſtead of being expelled.

It is with a view to this end that the diaphragm is eſpecially deſigned. The natural condition of the diaphragm is to be convex towards the lungs, and concave towards the abdomen, as it is found to be in the fœtal ſtate.

On the contrary, in the adult ſtate, when inſpiration has taken place, it is forced from this relaxed condition, by the diſtenſion which the lungs ſuſtain from the air they receive; ſo that its muſcular fibres contract, and by theſe means it becomes altered from a curve upwards to a plane. As ſoon, however, as this air becomes diminiſhed, either from abſorption, or from the loſs of its elaſticity, the diſtenſion which the bronchiæ had ſuſtained progreſſively goes off, the diaphragm returns into its original ſtate, and, in this act, the internal capacity of the thorax is diminiſhed in a longitudinal direction.

This action which the diaphragm performs ſeems to be independent of the will, and goes on during ſleep as perfectly as during a ſtate of watchfulneſs. The diaphragm appears to be an organ not neceſſary to the proceſs of inſpiration, but of expiration only. In its natural ſtate it muſt ever impede the proceſs of inſpiration; and it is only by the impetus of the air when it ruſhes into the bronchiæ from without, that this natural condition of the diaphragm is overcome, a contraction of its muſcular fibres produced, and the longitudinal direction of the thorax conſequently enlarged. I mention this circumſtance, becauſe anatomiſts of diſtinguiſhed reputation ſpeak and write about the diaphragm as if it were eſſential to the different proceſſes of reſpiration. Mr. Cruickſhank talks in ſome of his experiments upon dogs, of the animal breathing by means of the diaphragm only; and Mr. John Bell has made a particular arrangement of animals that breathe by means of a diaphragm, from thoſe that do not; and in his uſual manner ſhews a grim viſage to Mr. Hunter for ſome error which Mr. B. ſuppoſes Mr. H. has committed. I have heard of animals breathing by means of lungs, but never before by means of a diaphragm. Take the lungs away, and leave the diaphragm behind, what becomes of the breathing? Not ſo if the diaphragm be taken away and the lungs left—breathing may ſtill go on. There are various claſſes of animals that have lungs, but are deſtitute of a diaphragm, as fowls, &c. &c. And in quadrupeds and the human ſpecies itſelf, inſpiration will certainly take place without a diaphragm, and expiration alſo, although evidently in a more imperfect manner. It will take place from the depreſſion of the ribs, either by the loſs of power in the intercoſtal, or more eſpecially by the contraction of the abdominal muſcles. It appears to me, that in eaſy and in ordinary expirations, the diaphragm alone is adequate to the taſk: but when the quantity of azotic matter which had been diſcharged into the bronchia from the exhalant termination of the pulmonary arteries is conſiderable, and the power of the ſyſtem exhauſted; not the diaphragm alone, but the abdominal muſcles alſo co-operate in performing one and the ſame office *; ſo that, by the combined effect they produce, the internal capacity of the thorax is diminiſhed in all directions; the lungs become compreſſed and collapſed; the mechanical preſſure which the bronchia ſuſtain forces out the azotic air they contain through the medium of the trachea into the mouth,

---

* It is to prevent the effect of their motion from being felt by the abdominal viſcera that the omentum is eſpecially deſigned. Inſtead of deſcribing it as I have done, when I deſcribed the chylopoietic organs, I ought to have done it in this place.

from whence it is puffed out of the ſyſtem *.

That this excretory matter is deleterious and poiſonous to the ſyſtem by which it was produced, is evident to every one. No doubt can exiſt, but that if we were to inſpire again the air we expire; or if it were retained in the bronchia without expiring, that uneaſineſs and death itſelf would preſently enſue. That death in ſuch a caſe would not ariſe ſimply from the excluſion of vital air, but that it would be accelerated by the retention of the azotic, has been proved by experiments on dogs. The bronchia have been filled with carbonic air, and the ceſſation of all action ceaſed,

---

* Notwithſtanding the azotic nature of the blood which the pulmonary arteries return to the lungs, it is generally believed that it is employed by the lungs for their nouriſhment and ſupport. This idea has ariſen firſt from this circumſtance, that when adheſion of the lungs to the pleura coſtarum has taken place, the veſſels between both might be filled by injecting the pulmonary artery. It however appears moſt unphiloſophical to me, to make the phenomena of diſeaſe, the teſt of what takes place in a ſtate of health, when we know ſuch a teſt proves the very reverſe of it. And ſecondly, it has ariſen from the ſmall ſize of the bronchial arteries. There is however every rational ground to believe that they are equal to the taſk.

ceaſed, much more ſuddenly than by the mere excluſion of vital air *.

Exper. 1. Dr. Girtanner injected in the jugular vein of a dog a ſmall quantity of carbonic acid gas. He became ſleepy, died in twenty minutes, and the blood was found black.

Exper. 2. He injected in the jugular vein of another dog a ſmall quantity of azotic gas. The animal died in twenty ſeconds. Upon opening the thorax, pericardium and heart, the blood was found quite black alſo.

I have already written ſo much, that I am ſorry to ſay time will not permit me to extend the remaining part of this work as I firſt intended. Without therefore relating the different experiments which have been made with a view of aſcertaining the quantity and quality of the air which is expired—I ſhall merely ſtate the general fact, that carbonic acid gas ſeems to form the principal matter which is expelled in union with a ſmall proportion of nitrogen. It is probable that theſe different gaſes have in combination ſome of the moſt ſubtle parts of the machine, in a dead or in a decompoſed ſtate.

---

* How dreadful then was the condition of thoſe confined in the black-hole at Calcutta, who fell victims to the operation of foul air becauſe the Grand Mogul was not to have his nap diſturbed!—and more recently of thoſe unhappy wretches who were pent up in a ſmall veſſel from Jerſey during the period of a boiſterous night, and, in order that they might be preſerved from the danger of one element, fell miſerable victims to the more deadly operation of the other!

The probability I think is increaſed, from the noxious and deadly effects we behold frequently produced by the inhalation of air expired from the human body, whilſt it labours under different ſtates of diſeaſe. There is every reaſonable ground to ſuppoſe that theſe airs are the media in which are involved the poiſons of meaſles—of catarrh—of influenza—(a modification of catarrh) of typhus fever, and of plague itſelf. The particular nature of the action under which the ſyſtem labours, during the exiſtence of theſe ſeveral complaints, cauſes a difference in the mode of the decompoſition which the body undergoes. It is probably owing to the variety in this ſtate of decompoſition, that poiſons have particular modes of irritation when applied to another ſyſtem, which has not the power of reſiſting their operation*.

---

*This is a very important ſubject, and well deſerving of conſideration, becauſe it becomes a queſtion, how far poiſons might not be altogether obviated by chemical means, by the decompoſition of thoſe vapours which are either expired from the lungs, excreted from the ſurface of the ſkin, or that are given out by the total decompoſition of the whole ſyſtem after the actions of life have ceaſed. Improvements in this prophylactic branch have been made by the late Mr. Howard, "a friend of every clime, a patriot of the world." I muſt refer the reader to his invaluable work on lazarettos, and to a later publication on the ſame ſubject, by Dr. Carmichael Smith, not having leiſure to go into the ſubject at preſent.

I muſt not, however, omit relating a method recommended by Mr. Baldwin, the Britiſh Conſul at Alexandria in Egypt, for the cure of the plague. During a long reſidence in that country, he was led to believe that the uſe of ſweet olive oil applied to the ſkin might prove uſeful. He communicated his idea to the Rev. Dr. Louis De Pavia, twenty-ſeven years agent and chaplain to St. Anthony's hoſpital at Smyrna, who after five years experience, pronounced it to be the moſt efficacious remedy hitherto made uſe of. The plan is briefly as follows: As ſoon as a perſon is affected, he muſt be taken into a cloſe room, and over a brazier of hot coals, with a clean ſponge dipped in warm olive oil, his body muſt be very briſkly rubbed over for the purpoſe of producing perſpiration. During the friction, ſugar and juniper berries muſt be burned in the fire, which raiſe a denſe and hot ſmoke, that contributes to the effect. The friction to laſt four minutes. One pound of oil is ſufficient. Perſpiration generally enſues. The rubbing ought again to be repeated every day, until evident ſymptoms of recovery enſue, taking the utmoſt care to guard againſt cold. If tumours exiſt, they ſhould be rubbed over alſo. The moſt abſtemious diet is enjoined, merely of vermicelli boiled in water. Wine, &c. ſtrictly forbidden for forty days. There is no inſtance of any one who is employed in the act of rubbing having caught the contagion. Carefully anointing the body before is a preventative; and Mr. Baldwin declares, that amongſt upwards of one million of inhabitants carried off by the plague in Upper and Lower Egypt, during the ſpace of four years, he could not diſcover a ſingle oilman, or a dealer in oil.

CHAP. XXI.

ON DEATH.

Cauſed by the privation of living energy—the means conſiſt in the action of the excretory organs being ſtronger than that of the incretory—accompanied by a total ceſſation of organic action, and conſtitute the intermediate ſtate between organic action and diſſolution.

WHEN we reflect on the regular ſeries of progreſſion, perfection, and decay, which the animated ſyſtem generally undergoes, at different periods of its exiſtence; although the mode of its ſubſiſtence on things from without continues for the moſt part the ſame; we muſt be led to conclude, that the actions of the different organs which are more immediately ſubſervient to the evolution and preſervation of the ſyſtem, loſe the energy they poſſeſſed; whilſt, on the contrary, the actions of the excretory organs in general continue in full force; and that it is by the weakneſs of the one and power of the other, that natural death is produced.

It is the living principle, as we have ſeen before, in which the form and model of every corporeal frame reſides, and which becomes evolved by that principle imparting to the blood it receives, the character and ſhape which it eſſentially contains. If the principle of life were not definite in its eſſence, there could be no reaſon for living beings to have any limitation in their growth: ſo long as they were conſtantly ſupplied with proper nouriſhment, they might grow indefinitely and live to eternity. It is far otherwiſe: the evolution of the living principle is more active in the fœtal and infant ſtate, than at the period of youth; it terminates when that of manhood arrives, having then attained the acme of its perfection. The means by which it is attained, is from the ſupply being more abundant than the waſte. The means by which it is preſerved, is by the ſupply and waſte being equally balanced: and finally, it is loſt by the waſte being greater than the ſupply. Hence it is that every animated ſyſtem is eſſentially temporal in its energy; and the various parts of which it is compoſed, are in a ſtate of conſtant mutation and decay.

If the actions of the excretory organs, at the firſt period of life, were equal to thoſe of the incretory, the ſyſtem would remain ſtationary in infancy, as it does at the period of manhood, without ever arriving at it. And if the actions of the excretory organs were not greater in old age, than in infancy and manhood, there could be no diminution in the ſize of the ſyſtem; the whole would be an evergreen, never perhaps liable to periſh or decay. But, alas! this period does arrive; it is brought on by the loſs of the balance between the veſſels ſubſervient to the growth and to the decreaſe of the ſyſtem. The change is gradual, but it is conſtant and uninterrupted; the arteries are relatively empty, and the veins full, with relation to the arteries.—All, all is waſte and no ſupply; the different organs loſe the power which they originally poſſeſſed, of imparting any vital energy to the different ſubſtances that are applied to them, or even of retaining their own:—the balance is upſet, and both ſcales are put into one!!! So that when the powers of the ſyſtem become ſo far exhauſted, either from the effects of diſeaſe, or the preſſure and infirmities of age, a total abolition of all ſenſe and ſenſation, of all conſciouſneſs and voluntary power, enſues;—the different muſcles, voluntary, involuntary, and mixed, whoſe action depended on the energy they ought to receive from the brain and nerves, become in the moſt perfectly paralytic ſtate that can be conceived or deſcribed. The collapſed ſtate of the lungs prevents the tranſmiſſion of the blood from the right to the left ſide of the heart, ſo that a conſequent accumulation takes place in the pulmonary artery, in the right auricle-ventricle, and venous ſyſtem; the exhalant termination of the arteries becomes relaxed; and inſtead of effuſing mere vapour in the different circumſcribed cavities, viz. ventricles of the brain—pericardium—thorax—abdomen, and tunica vaginalis, ſerous fluid is found to have been depoſited in them*.

The different fluids which were contained either in the gall-bladder, or bladder of urine, are found to tranſude through their pores, inſtead of being retained: and inſtead of ſecretion taking place, there is a total ceſſation of action, ſo that that condition of the ſyſtem is induced, which is known under the appellation of death.

Death is that intermediate ſtate between the powers of life, when they are diſplayed in organic action, and the ceſſation of organic action, to the final diſſolution of the whole machine into its conſtituent parts.

---

* It may be proper here to mention, that by opening living animals, theſe different cavities are found totally deſtitute of any fluid—vapour alone conſtituting the medium with which they are filled. On the contrary, after the actions of life have ceaſed, theſe cavities are always found to abound with a ſerous fluid.

Life conſiſts not only in the actual preſence of preſervation, but of organic action alſo. *Death* conſiſts in the loſs of ſpecific action, whilſt the powers of preſervation ſtill remain; but diſſolution proceeds from the total loſs of both, not only of organic action, but of preſervation alſo, and is accompanied by a ſeparation and decompoſition of the ſyſtem altogether into its conſtituent parts. However different the means may be by which death and diſſolution may be produced, the end is certainly the ſame.

Mr. Hunter, on the contrary, thought that mortification was of two kinds; one with, the other without inflammation. He however miſtook the means by which death was produced for the thing itſelf. The death of one ſyſtem, or the life of one ſyſtem, is of one kind only. There are various means by which life is ſupported, and there are various means by which it is deſtroyed. But one ſyſtem has one life only, not many lives; ſo one living ſyſtem can only have one death, not many deaths, although there may be many different modes by which that death may be produced *.

CHAP. XXII.

ON DISSOLUTION, CAUSED BY THE ENERGY OF NATURE.

NATURE *the agent by which it is cauſed—putrefaction and fermentation the means—a total decompoſition between all the parts—the effect produced in the end—Nature and Life examined, and found totally oppoſite in their action—Life the organizing—Nature the diſorganizing principle, &c.*

THUS then it appears, that ſuch is the temporal nature of all generated (animated) beings, that although they riſe to perfection, by employing the various ſubſtances ſubſervient to their uſe, they ultimately verge to decay. They verge to decay as ſoon as the matter which had received the participation of life ceaſes to retain its energy. The bond of their elementary parts becomes looſened by an inteſtine motion, the whole organic fabric becomes totally decompoſed, and reſolved from an organized to a diſorganized ſtate, and finally is reduced from a dead to a common one*.

---

* It is obſerved by perſons who are in the habit of attending executions, that the penis is found in an erected ſtate after ſtrangulation has taken place: and I was informed by a general officer, who ſerved laſt war in India, that after different battles which had been fought, he went over the field, and was much ſurpriſed to find the penes of the ſepoys who were killed, erected to an aſtoniſhing ſize (in that country they are not clad as we are in Europe). The cauſe of this diſtenſion, I imagine, muſt ariſe from an obſtruction of the blood through the right ſide of the heart, and an accumulation taking place in the whole venous ſyſtem.

Admitting then, that it is by the participation of life that common matter is made living, and that it conſtitutes the bond of union between its various parts,—does it not appear reaſonable to conclude, that there muſt exiſt ſome active agent by means of which this living matter loſes this participation of life, and through whoſe power vegetables and animals are made ſeverally to undergo the ſpontaneous changes of fermentation and of putrefaction? It is thus that it altogether ceaſes to continue under the particular controul of the living principle to which it originally belonged, and then becomes amenable to the law of phyſics in general.

---

* I muſt requeſt that the reader will refer to vol. i. page 31 to page 35, as I have particularly deſcribed the phenomena that take place during the proceſſes of diſſolution or decompoſition, and which it is very material to comprehend.

It appears very probable to me, that that principle which we call NATURE, conſtitutes the bond of the elementary parts of which common matter is compoſed, and which forms what is vulgarly called the *attraction of coheſion*;—that it is the grand agent which becomes the efficient cauſe of the ſpontaneous changes we behold in different ſpecies of common matter; and that putrefaction and fermentation are the means which nature employs to bring back living matter to a common ſtate.

Nature is as much the active and efficient cauſe of the various phenomena which common matter diſplays, as the principle of life itſelf is the cauſe of action in that which is living. Nature is as much the bond between the different parts of which common matter is compoſed, as the principle of life is the bond between the various parts of which a whole living ſyſtem conſiſts. Nature is the cauſe of coheſion in common matter. Life is the cauſe of coheſion in living. Nature is the active and general principle by which common matter is made to act. Life is the active and particular principle by means of which common matter is ſeparated from its elementary ſtate; by which it is changed from its natural condition, and compelled to aſſume the particular organized forms that are imparted to it by the various living principles with which the univerſe is replete.

The principle of life acts upon common matter, ſeparates it from its elementary ſtate, and imparts to it properties of its own by means of which its paſſive or natural tendency is overcome: and thus it is made to acquire the particular powers of the animated ſyſtem to which it belongs; an infinite variety of action is produced, and no correſpondence ſeems to exiſt between the effect and the cauſe.

The difference therefore that exiſts between the action of life and of nature conſiſts in this: the firſt acts upon common matter to make it living, the laſt acts upon living matter to make it common. Union and aſſimilation are the effects of the one, ſeparation and putrefaction are the effects of the other. The action of life is to preſerve matter in an organized ſtate— the action of nature is to reſolve this organized matter into a common one: the motion of the living ſyſtem has remiſſion, and is more active at one time than at another; the motions that are cauſed by the energy of nature on matter deprived of its living and preſervative powers are conſtant and continued, until the whole is decompoſed into its conſtituent parts.

If nature and life are examined with reſpect to the extent of their powers, the firſt will be found as different from the other as it is in the peculiarity of its action. Nature pervades the whole ſyſtem of the univerſe, extending her energy to the moſt minute particles of matter. Life is limited to a particular ſubject, perfect only when forming one complete ſyſtem. Nature makes parts return to their wholes: Life makes a whole ſyſtem only from various parts.

So long as the different elements of which the univerſe is compoſed occupy their proper and ſubordinate ſituations, nature continues at reſt. On the contrary, when this order is diſturbed, whether it proceed from common matter having been ſeparated from its elementary ſtate, and made living, or from many different ſpecies of matter combining together; in every caſe whatever, it muſt be conſidered as a diſturbed and a violent ſtate, and the various phenomena of elective attraction, and of fermentation,

tation, putrefaction and gravitation are produced.

Putrefaction and fermentation are the means which nature employs to bring back living matter to a common ſtate. Whilſt it ſubſiſted in a living condition, it was wholly ſubſervient to the controul of the living principle by whoſe power it had been organized, and was wholly amenable to its laws. On the contrary, after this living matter has been decompoſed by the proceſſes of fermentation or of putrefaction, it ceaſes to continue under the particular controul of the living principle to which it belonged, and becomes amenable to the laws of phyſics in general. It obeys the laws of chemical attraction, and unites with matter, whoſe ſenſible qualities are different from thoſe which it poſſeſſes; new combinations are formed, and the various ſenſible properties are produced, which we behold different inanimate bodies ſeverally poſſeſs.

This common matter not only obeys the laws of chemical attraction, but of ſpecific gravity alſo; it either riſes—remains ſtationary—or falls, according to the quantity of matter which it contains, with relation to the medium by which it is ſurrounded; and thus it is that it finds its proper level. Chemical union and gravitation, therefore, aſſiſt in completing what putrefaction and fermentation had begun. The final cauſe which nature has in view, is to preſerve the order of the elements of which the univerſe is compoſed, and to make the various parts that have been ſeparated from their ſource return to them.

It is with a view of examining the particular qualities which bodies have attained by theſe various changes, that the ſcience of chemiſtry is deſigned; a ſcience that has contributed as much to the advancement of the arts, and the corporeal comforts of human life, as the ſcience of mind has to the inveſtigation of principle and the eſtabliſhment of truth. Such is the regularity that exiſts in the operations of nature on common matter, that the various changes which different bodies undergo, are uniformly the ſame, when the circumſtances are alike in which they are placed; ſo that an experienced chemiſt can tell à priori what ſhall be the reſult.

But chemiſtry does only in detail what nature does in the groſs. The wonderful phenomena that are produced by natural means, attend and the ſtability and uniformity that invariably attend them, impreſs the mind with awe and admiration; they diſpoſe it to ſearch into the attributes of Deity itſelf,—of that infinite wiſdom, which employs different ſubordinate and inſtrumental agents in the government of the world, where all is regularity without apparent deſign, all action in matter that is endowed with total paſſivity.

When we reflect on the various agents which the principle of life evolves, with a view of preparing different ſubſtances, and fitting them to receive the participation of the power of particular organs, we ſhall be led to admit the truth of that important axiom I have already mentioned, *Quidquid recipitur, recipitur in modum recipientis.* We ſhall do more: we ſhall apply it to the agency of nature upon common matter, and admit that nature exiſts as the inſtrumental cauſe which the Deity employs for the phyſical government of the world, by means of which the parts are united in one whole, and through whoſe power the various phenomena are produced.—Between common matter, which is infinitely diviſible, and the Deity, which is totally indiviſible—between matter which is totally imbecile and inert, and Deity, which is eſſentially intelligent and active, *Nature* exiſts as the connecting medium between both, which being eſſentially proximate to common matter in general by which it is received, and through which it acts, is conſequently inſeparable from it—participating in ſome degree a diviſible and material nature, by the quality of the matter by which it is received—as it does an incorporeal and an indiviſible one from the Deity itſelf, of which it is an emanation *.

---

* I know perfectly well, that theſe obſervations will be conſidered by ſome as merely viſionary and ſpeculative, having no exiſtence in truth or in fact. I can only ſay, that I am convinced to the contrary, and that I have the authority of ſome of the wiſeſt and beſt men both in ancient and even in modern times. That great and good man Biſhop Newton ſays, "It is certain that the philoſophy of the age attributes too much to matter and the powers of matter, and too little to ſpirit; whereas, in reality, the one is never more than an inſtrument; the other is always the agent. The principle of gravitation itſelf, anſwering, as is very well known, not to the ſurface of bodies, but to their ſolid content, cannot poſſibly be accounted for by any action of matter upon matter; but muſt of neceſſity be reſolved into ſome immaterial cauſe, that penetrates the inmoſt ſubſtances of things, and exerts a power of which matter is altogether inſenſible." *Biſhop Newton.*

Nature works as it were perpetually without fatigue,—preſerves and reſtores order and ſubordination in common matter without foreign aſſiſtance or deſign. On the contrary, the powers of all animated beings are exhauſted by their work; they are indigent of a ſubject foreign to themſelves; and after having attained their ſtate of perfection, they perpetually verge to decay. Whilſt, therefore, we witneſs the iſolated ſtate and impotent power of all animated ſyſtems in common with thoſe of man, not only finite in power, but finite in number, temporal in their energy, helpleſs, infinite! we behold the regular and extended operations of nature in an uninterrupted ſeries —the changes of day and night, ſummer and winter, and all the different phenomena which the univerſe diſplays. It was with a view to this I ſaid, * " that the ſyſtem of nature is a ſyſtem founded on ſymmetry and order, and governed by general laws; that theſe laws are all ſubſervient to the preſervation of this economy, and that the objects dependent on this economy are the elements.

---

[*] Vide my Treatiſe on the Proceſſion of the Elements.

Theſe elements proceed from the moſt excellent and rare to the moſt indigent and ſolid. Although the different elements are at preſent combined and united; there can be no doubt that the combination of the parts has a reference to the original elements from which they proceed; that theſe elements are *wholes* with reſpect to *parts*; and that the principle which governs theſe parts, has for its object the preſervation of the order and gradation of the whole" It appears very evident indeed, that there is a regular gradation in the elements of this ſenſible univerſe, and that velocity of motion is as inherent in light, as total paſſivity is the inherent attribute of earth. Between theſe water and air exiſt, concatenating the two extremes and uniting all the parts in one whole. Nature is the efficient cauſe, as we have ſeen before, by which this ſymmetry is preſerved; it ſuperintends the phenomena of the material world, governs by general and unerring laws the different elements of which it is compoſed, preſerves the order and ſubordination of the whole, by making the parts return to their original elements after the end is accompliſhed for which they were ſeparated.

rated. It makes them return to that extended ſubſtance that is deprived of all power and of all action; that is imbecile and inert; that is formleſs and motionleſs; that moves becauſe it is moved; that acts becauſe it is acted upon; that becomes figured becauſe it receives impreſſions from ſome external agent.

It is by tracing the ſyſtem of the univerſe from things beſt to things worſt; from animated beings to ſuch as are inanimate; from the agent to the patient; from the cauſe to the infinity of its effects; from things compoſite to things ſimple; that we ultimately arrive at the contemplation of that primary and elementary matter, of which the whole of the univerſe is compoſed and filled.

This primary matter is truly elementary with regard to figure and form: if it poſſeſſed any particular form, it would be unfit to receive the impreſſions that are imparted to it. Hence it is in its nature formleſs; it bears the ſame relation to figure, that the paper on which I write does to the letters I am writing. If the paper poſſeſſed any particular colour or figure, it would be unfit to receive the impreſſions I am now ſtamping on it. It is by virtue of this total privation of all particular quality, that it poſſeſſes the general aptitude of receiving all qualities:—any individual quality it might retain would diminiſh the aptitude it has of being a general recipient of all.

Every quality is power in a certain reſpect, and this quality would give it the power of reſiſtance, ſo that other qualities could not be received without the departure of the original. If this were poſſible, two things could exiſt in the ſame ſubject together, in the ſame place at one and the ſame time. Hence we ſee the neceſſity of the exiſtence of ſimple elementary matter prior to ſuch as is organized and compoſed. Blood bears the ſame relation to the organs as elementary matter does to compoſite—it poſſeſſes aptitude alone, and no particular power. It therefore is wholly ſubſervient to the action of the organs, and by them becomes organized. It is the ſame with voice, which poſſeſſing no other quality than the general one of ſound, becomes fitted to be harmonized by the particular organs of ſpeech; and hence it is that language is produced *.

---

* Since then we muſt allow that ſimple matter had an

exiſtence prior to that which is compoſite, it follows, that all the matter we now behold in a compounded and combined form, although compoſed from primary matter, is not in its elementary ſtate. Elementary matter conſtitutes the whole in its moſt ſimple and original form, and organized matter proceeds from ſimple matter in its moſt complicated ſtate. Elementary matter is the whole, and organized matter parts of that whole. The whole therefore comprehends, and the parts are comprehended. If the parts exiſted before the whole, the effect would be better than the cauſe, the parts would comprehend, and the whole be comprehended. It might as well be ſaid, that the different organs of man were firſt formed before the power that formed them.

CHAP. XXIII.

OF COMMON MATTER.

The different ſpecies—the cauſe of elective attraction—the ſun the fountain of light, neither hot nor cold—by its combination with opaque matter heat is produced—comets very numerous, &c.

VAIN were the attempts to ſearch for the elementary properties of common matter in a region like that in which we reſide, where all is mixture and confuſion; where corruption is the neceſſary conſequence of animation, and animation itſelf is fed by the materials which proceed from the corruption and decompoſition of bodies that were once animated.

By the efforts of the chemiſts, of thoſe eminent men that have analyſed as far as they were capable the moſt minute particles of matter, who have aſcertained the order of their affinities and ſpecific gravities, and who by diligence and zeal have contributed in a very diſtinguiſhed degree to improve the arts, and ſupply the various corporeal comforts of human life, the general qualities of matter have been aſcertained. None I believe have however pretended to affirm, that they have yet diſcovered what was the elementary conſtituent of any one ſpecies of matter. It is from the neceſſity of its exiſtence, more perhaps than from any particular attribute we know it poſſeſſes, that we are led to conclude, that matter of a pure elementary nature has an actual ſubſiſtence.

" Although the different elements are at preſent combined and united, there can be no doubt, that the combination of parts has a reference to the original elements from which they proceed; that theſe elements are *wholes*, with reſpect to *parts*; and that the principle (Nature) which governs theſe parts, has for its object the preſervation of the order and gradation of the whole."

Elementary matter of different kinds ſeems abſolutely neceſſary, to preſerve the regular gradation that exiſts between the different parts, in order to perfect the univerſality of the whole. Admitting this neceſſity,

ceſſity, we may conclude that the original elements are homogeneous in their nature, preſerving a certain relation to each other, which permits the mutual union of each proximate element without violence: thus we find light and air—air and water—water and earth, all ſeparately uniting in amicable conjunction. And as the gradation of theſe elements proceeds from the moſt rare to the moſt ſolid; light ranks as the firſt element, and earth as the laſt. Whenever theſe extreme parts unite by the diſpoſſeſſion of the intermediate element, violence is the conſequence. It is on this principle that the doctrine of chemical or elective attraction is founded. It depends not on the homogeneous quality, but on the contrariety that ſubſiſts between oppoſite and extreme bodies. The degree of purity of one element, and the degree of impurity of another, is the law upon which it is founded. It is owing to the operation of this law, that the matter of light in union with atmoſpheric matter produces the matter of heat.

That the ſun is the ſource from whence the matter of light immediately proceeds, is evidently proved, from the illumination it imparts to our organs of ſight; and from the profound darkneſs in which we are involved, when we are removed from the influence of its rays.

The ſun is not only the grand fountain of light, but it appears to be one of the principal agents in the production of heat. That this is the caſe, is proved by comparing the temperature of different latitudes, and different degrees of altitude of the ſame latitude, with each other. Although the temperature of the air, when meaſured on the ſurface of the plain under the line, is totally different from the temperature of the plain at the poles, if it be meaſured at certain diſtances from the plain, as on the ſummit of the moſt lofty mountains, yet the temperature in all latitudes at top is preciſely the ſame, and all are there found to be moſt intenſely cold. It is the caſe with the ſummit of the Andes, ſituated immediately under the line, with the Cordeleras, the Alps and Appenines—the Peak of Teneriff, and in ſhort, of all mountains of conſiderable altitude. Although the temperature on the plain is intenſely hot in all theſe, it perpetually decreaſes in its aſcent, until the cold is found ſo exceſſive as to be unfit for the exiſtence of human life, and can only be apprehended by the vaſt coverings of ſnow with which thoſe mountains are perpetually coated.

If the ſun therefore were eſſentially hot, (per ſe) and the matter of heat the ſame as the matter of light, it muſt evidently follow that the degree of heat would increaſe in proportion as the ſun was approached. It ought therefore to be colder and darker on the plain, than on the ſummit of lofty mountains,—hotter and more light on the moſt lofty ſummit of the moſt lofty mountain than on the plain. It is far otherwiſe. It is lighter, but colder, at top than at bottom; darker, but hotter, at bottom than at top. The pure matter of light therefore is not the ſame as the matter of heat, although one of the conſtituent parts for its production. The queſtion then is, How does the matter of light produce the matter of heat?

Having already diſcuſſed, and, I confeſs myſelf vain enough to believe, aſcertained the cauſe of heat, I muſt refer the reader to my Treatiſe on the Proceſſion of the Elements, which contains the diſcuſſion of the ſubject. I do not arrogate to myſelf the merit of having been the firſt man that ventured to overturn the Newtonian hypotheſis, which aſſerts the ſun to be a ball of fire, and all the different heavenly bodies inert maſſes of ſolid earth like our own. I think it however a juſtice I owe myſelf, to ſtate, that various circumſtances have ariſen ſince the publication of that work, to confirm me in the opinion I therein advanced, viz. that the ſun was neither hot nor cold, but was conſtituted of pure matter of light only. That the rays which perpetually emanate from the ſun as their ſource, conſtitute the pureſt ſpecies of matter of which we have any conception or knowledge. That as they proceed from the ſun, they are perpetually combining with the opake or atmoſpheric matter with which they come in contact, producing the various phenomena of comets, meteors, lightning, atmoſpheric and culinary heat. It is by a chemical union of this matter of light with atmoſpheric matter, that heat is generated. The pure matter of light, or ſolar rays, I conceive, conſtitutes the caloric of the preſent chemiſts. It is, I preſume, by the combination of this caloric, not by the decompoſition of it, that ſenſible heat or fire is produced; poſſeſſing properties in its combined ſtate very different from what it did in its ſimple one. In its pure or uncombined ſtate, it is what is called latent heat: in its compound or combined ſtate, it is called ſenſible heat.

I muſt further add, that in that work I advanced it as my opinion that COMETS were bodies deſtined to conſume any opaque or atmoſpheric matter that may have inſinuated itſelf beyond its proper region; ſo that they form the boundaries or lines of demarcation, by means of which the matter of one ſyſtem is prevented from interfering with that of the other. I pointed out the evils that would neceſſarily ariſe if ſuch bodies as comets did not exiſt: viz. not only that the upper region would either be a region of darkneſs or of fire; but that the medium in which the various planets moved, would be rendered of different degrees of denſity at different times:—and thus it would happen, that the variety of reſiſtance in this medium would interfere with the regularity in the motion of the planets. Foreſeeing theſe conſequences as inevitable, I ventured to aſſert, that comets were bodies that univerſally abounded in the upper regions, or in the inferior part of the medium of light; that it was only a proof of the inſufficiency of ocular obſervation, that they were ſo ſeldom diſcovered; and that there was an abſolute neceſſity for the exiſtence of comets of different claſſes that deſcribe different orbits, and make their appearance at different times*.

I publiſhed this book in the month of *January* 1795. In the firſt part of the Philoſophical Tranſactions of the ſame year, and which was publiſhed in the month of July, there is a long paper in it written by Dr. Herſchel; whoſe name it is only neceſſary to mention to give authority to whatever he advances. In that paper there are a variety of facts, with reſpect to the ſun, which I had already advanced, and with reſpect to comets. Of thoſe bodies, that I formerly underſtood were limited by aſtronomers to nine, but which I aſſerted were numerous, Dr. Herſchel ſays: “Many of the operations of Nature are carried on in her

---

[*] Page 233--234. See Chapter on Comets, from page 229 to page 250.

great laboratory in a manner which we cannot comprehend; but now and then we ſee ſome of the tools with which ſhe is at work. We need not wonder, that their conſtruction ſhould be ſo ſingular as to induce us to confeſs our ignorance of the method of employing them; but we may be aſſured that they are not a mere luſus naturæ. *I allude* (the Doctor goes on to ſay) *to the great number of ſmall teleſcopic comets that have been obſerved, and to the far greater number ſtill that are probably much too ſmall for being noticed by our moſt diligent ſearchers after them. Thoſe ſix for inſtance which my ſiſter has diſcovered, I can from examination affirm, had not the leaſt appearance of any ſolid nucleus, and ſeemed to be mere collections of vapours condenſed about a centre. Five more that I have obſerved alſo, were nearly of the ſame nature. This throws a myſtery over their deſtination, which ſeems to place them in the allegorical view of tools, probably deſigned for ſome ſalutary purpoſes to be wrought by them; and whether the reſtoration of what is loſt to the ſun by the emiſſion of light, the poſſibility of which we have been mentioning above, may not be* *be one of the purpoſes, I ſhall not preſume to determine*," &c. &c.

I reſpect Dr. Herſchel too much to accuſe him directly of plagiariſm. It is, however, a little extraordinary that this paper ſhould have been preſented to the Royal Society a few months only after my book was publiſhed, in which the Doctor aſcribed to lightning, meteors, comets, the very uſe which I had done before—that I ſhould aſſert the neceſſity of their exiſtence, and that the Doctor ſhould afterwards declare that he ſaw them, and was of my opinion (without mentioning it);—that they exiſted more generally than we were able to diſcover;—that they were compoſed of the ſame kind of matter as I had aſſerted, and deſigned for the ſame uſe. Without wiſhing even to ſuſpect that Dr. Herſchel had ever ſeen my book, I think it juſt to ſay, that the truth of my hypotheſis is ſtrengthened by Dr. Herſchel's opinion, and confirmed by his diſcoveries. The quantity of rain that has fallen during this ſummer, is nothing elſe than might have been expected from the operation of the comet that we have lately ſeen. The elaſticity of the air in the upper region, has no doubt been conſiderably diminiſhed, and its power alſo of ſuſpending water; and hence the cauſe why we have had ſuch inceſſant rains, the effects of which have been felt from the ſpring to the preſent day.

The officer who has the care of the telegraph at the Iſle of Wight, and who keeps a regiſter of the weather, obſerved, that there have been only nine days ſucceſſively without rain, from the 25th of March to the 25th of October; and during the month of November to the preſent day, the 18th of December, we have ſcarcely had one continued day of dry weather.

It was my intention to have inveſtigated the Newtonian laws of Nature; but ſuch is the magnitude to which this volume is ſwelled, that I am compelled to defer it to ſome future opportunity. I ſhall therefore confine myſelf to give an arrangement of the different ſpecies of matter; but muſt refer the reader to Dr. Babington's Syſtematic Arrangement of Minerals, whoſe extenſive knowledge of chemiſtry is equalled by few and excelled by none. That arrangement is founded on the joint conſideration of their chemical, phyſical and external characters, reduced to the form of tables, and exhibiting the analyſis of ſuch ſpecies as have hitherto been made the ſubject of experiment.

CHAP. XXIV.

OF THE ARRANGEMENT OF DIFFERENT SPECIES OF COMMON MATTER.

CLASS I.

1. PURE SOLAR RAYS. *Matter of light*, called by the French chemiſts *lumiere*, and which I conceive to be ſynonymous to the *caloric of the preſent day*, in its pure and uncombined ſtate.

2. OXYGEN GAS, compoſed of caloric in combination with other baſes, is obtained in a ſeparate ſtate from metallic oxyds and compounds of the nitric and other acids, by the application of heat.

3. AZOTIC GAS, or NITROGENE, obtained in its pureſt ſtate from a mixture of oxy-muriatic acid and ammoniacal gaſes.

4. HYDROGEN GAS, OR INFLAMMABLE

AIR, is found diſengaged in coal mines, on the ſurface of ſtagnant waters, riſing through the waters of particular ſprings, and is obtained from the diſtillation of matter of an animal, vegetable, and bituminous kind.

5. CARBONIC ACID GAS, or FIXED AIR.

6. ATMOSPHERICAL AIR. By analyſis and ſyntheſis the inferior ſtratum is found to be compoſed of two parts, viz. of oxygene and nitrogene gas. It is however ſubject to ſuch various viciſſitudes, that no doubt can exiſt but that there are other bodies in union with it, either diſſolved or mechanically diffuſed.

7. HEPATIC AIR.

CLASS II. OF FLUIDS.

1. Alcohol, phoſphorus, eſſential and unctuous oils, balſams, fat, butter, &c. &c. &c.

2. WATER. Suppoſed to be compoſed of oxygene and of hydrogen gas.

2d Genus. Acids are diſtinguiſhable by being ſour to the taſte, changing vegetable *blue* colours to a *red*. They may be divided into three orders—into the *animal*, *vegetable*, and *mineral*, according to the ſource from whence they are moſt abundantly obtained.

The ANIMAL ACIDS are the *phoſphoric, lactic, ſaccharo-lactic, formic, ſebacic, lithic* and *bombic.*

The VEGETABLE ACIDS are the acetic, tartareous, pyro-tartareous, oxalic, gallic, citric, malic, benzoic, pyro-ligneous, pyro-mucous, and camphoric.

The MINERAL ACIDS are the ſulphuric, nitric, muriatic, carbonic, fluoric, boracic, ſuccinic, arſenic, tungſtenic, and molybdenic.

CLASS III. OF SOLIDS.

Genus 1. Alkaline ſalts—characteriſtics—diſtinguiſhed by being of a pungent, lixivial, or urinous taſte, and changing moſt vegetable *blue* colours to *green*, and many of the yellows to *brown.* They are divided into *fixed* and *volatile*; the fixed are ſubdivided into *vegetable* and *mineral.*

Species 1. VEGETABLE ALKALI. POTASH. It appears to be a conſtituent part of moſt vegetable ſubſtances, and is obtained from *carbonate of potaſh* by treatment with lime.

2. MINERAL ALKALI. SODA. Is found in great abundance in the animal kingdom, particularly in combination with muriatic acid,

obtained in a ſeparate form from carbonate of ſoda, by means of lime.

3. Volatile alkali (ammoniac) obtained from the decompoſition of muriate of ammoniac by potaſh, ſoda, or lime.

CLASS IV. INFLAMMABLE BODIES OBTAINED FROM THE VEGETABLE KINGDOM.

Hydrogene gas, alcohol, bituminous bodies —and are either liquid, and deſtitute of colour, as naphtha; or more or leſs liquid, and of a dark colour, as petroleum, Barbadoes tar; or ſolid black, and of a compact or ſlaty texture, as aſphaltum, jet, coal, charcoal: they appear from a variety of circumſtances to be of a vegetable origin, as well as amber.

Genus 2. INFLAMMABLE BODIES OBTAINED FROM THE ANIMAL KINGDOM.—Phoſphorus, hydrogene gas, unctuous and eſſential oils, butter, fat, bees-wax, ſpermaceti, balſams and reſins obtained from the decompoſition of both animal and vegetable matter. Camphor.

3. INFLAMMABLE BODIES OBTAINED

FROM THE MINERAL REPUBLIC.—Sulphur, plumbago, the diamond, &c. &c.*

CLASS V. OF METALS.

Metals are diſtinguiſhed by their weight, opacity and ſplendour; alſo remarkable for their power of conducting the electrical fluid. They are preſented to us by nature under different forms. 1ſt. Native, *i. e.* when in poſſeſſion of the properties juſt mentioned. 2d. Oxydated in union with oxygene. 3d. Saline, or united with one or other of the acids. 4th.

---

* From ſome late obſervations on the muſcles of different animals, it is found, by expoſure to a current of water for a conſiderable time, that they become converted into a ſubſtance ſomewhat ſimilar to ſpermaceti. Mr. Gibbs, an ingenious ſurgeon at Bath, has given in a paper to the Royal Society upon the ſubject.

It has been diſcovered alſo, that the muſcles of the human ſpecies are equally ſuſceptible of undergoing the ſame alteration, forming tallow of the fineſt quality. This human tallow has been melted down into candles. Theſe candles were found upon trial to give out a remarkably delicate flame of a blueiſh caſt. A manufactory of them would probably have been ſet up by this time, had it not been for the vigilance of the police. It may, however, be ſuſpected, that whenever the candles burn blue, ſome adulteration has been employed.

Genus

Mineralized, or combined with ſulphur; and 5th, Alloyed, or in union with each other.

Metals are divided into two genera—the perfect and imperfect.

Genus 1. The PERFECT METALS are, *platina*, *gold*, and *ſilver*.

2. THE IMPERFECT METALS are, *quickſilver*, *lead*, *copper*, *iron*, and *tin*.

Genus 2. THE IMPERFECT or SEMI-METALS are, biſmuth, nickel, arſenic, cobalt, zinc, antimony, manganeſe, tungſtein, uranite, molybdena, and monachanite.

CLASS VI. VOLCANIC PRODUCTIONS.

1. Cinders—looſe or coherent. The looſe are aſhes and ſand; the coherent are puzzolana, traſs, tufa, pumice, peperino.

2. Lava—either common or vitreous.

Common lava is either cellular or compact.

Vitreous lava—glaſs, enamel, ſcoriæ, ſlags.

CLASS VII. OF EARTHS.

They are diſtinguiſhed by their brittleneſs, fixity, ſparing ſolubility in water, inſipidity, want of odour, incapacity of imparting a tinge to glaſs, and their ſpecific gravity not exceeding

ing that of water more than in the proportion of 5 to 1, and are diviſible into nine genera. 1. Lime, or calcareous earth. 2. Strontian earth. 3. Magneſia or muriatic earth. 4. Adamantine earth*. 5. Jargan earth†. 6. Sedmean earth‡. 7. Siliceous earth, or quartz. 8. Argillaceous earth, or clay. 9. And finally, Barytes, or TERRA PONDEROSA.

---

[*] This is ſuppoſed doubtful.

[†] Certain.

[‡] The exiſtence of it is denied.

THE END.